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DUHS KARACHI

DUHS Karachi MDCAT 2025 Official Paper

Official Annual Full-Length Practice Examination (FLP) · Complete Solved Paper

📌 Official Admitting Board: Dow University of Health Sciences Karachi 📌 Archive Code: BEAMBE-FLP-DUHS-2025 ⌚ Duration: 210 Minutes (3h 30m)

180
TOTAL QUESTIONS

210m
OFFICIAL DURATION

+1 / 0.00
ZERO NEGATIVE MARKING

180
MAXIMUM MARKS

📄 EXAMINATION BLUEPRINT & SUBJECT WEIGHTAGE

English
9 MCQs
5.0% weight

Biology
82 MCQs
45.6% weight

Chemistry
44 MCQs
24.4% weight

Physics
36 MCQs
20.0% weight

Logical Reasoning
9 MCQs
5.0% weight

ENG SECTION: ENGLISH

Questions 1 to 9 (9 MCQs)

Q1. ENG

He said, "Will you listen to such a man?" Choose the most appropriate indirect speech:

- (A) He asked them that they would listen to such a man.
- (B) He asked them whether they would listen to such a man.
- (C) He told them whether they will listen to such a man.
- (D) He asked them to listen to such a man.

Q2. ENG

"His lachrymose speech at the funeral moved everyone to tears." Choose the synonym for lachrymose:

- (A) Joyful
- (B) Weepy
- (C) Monotonous
- (D) Humorous

Q3. ENG

Identify the simile:

- (A) She trembled like a leaf in the wind.
- (B) She was a statue, frozen in fear.
- (C) She was drowning in doubt.
- (D) Her thoughts were a whirlwind.

Q4. ENG

The board will approve the budget only after the auditor verifies the accounts. The most appropriate passive voice is:

- (A) The budget will be approved by the board only after the accounts are verified by the auditor.
- (B) The budget is approved by the board only after the accounts have been verified by the auditor.
- (C) The budget is being approved by the board only after the accounts are verified by the auditor.
- (D) The budget has been approved by the board only after the accounts were verified by the auditor.

Q5. ENG

He does his work without any care. The underlined part of the sentence is an:

- (A) Adverb phrase
- (B) Adjective phrase
- (C) Noun phrase
- (D) Appositive phrase

Q6. ENG

The purpose of using exaggerated language in parody is:

- (A) To create a serious tone
- (B) To criticize societal norms
- (C) To entertain and mock
- (D) To confuse the reader

Q7. ENG

Choose the correct sentence:

- (A) The new policy aims at reduce waste, to promote recycling, and creating awareness among citizens.
- (B) The new policy aims to reducing waste, promoting recycling, and create awareness among citizens.
- (C) The new policy aims to reduce waste, to promote recycling, and creating awareness among citizens.
- (D) The new policy aims to reduce waste, promote recycling, and create awareness among citizens.

Q8. ENG

Choose the word with incorrect spelling:

- (A) Immigrant
- (B) Ancestors
- (C) Montessori
- (D) Pregmetic

Q9. ENG

Choose the sentence in which "only" indicates that Jamila was the only person who spoke about her tiredness:

- (A) Only Jamila said she was tired.
- (B) Jamila only said she was tired.
- (C) Jamila said only she was tired.
- (D) Jamila said she was only tired.

BIO SECTION: BIOLOGY

Questions 10 to 91 (82 MCQs)

Q10. BIO

A person has swollen lymph nodes after throat infection. What does this indicate?

- (A) Failure of circulatory system
- (B) Extra glucose storage
- (C) Active immune response
- (D) Blockage of digestive tract

Q11. BIO

Monoclonal antibodies are useful in cancer diagnosis by:

- (A) Replacing damaged tissue
- (B) Changing the genetic code of cancer cells
- (C) Killing healthy cells to reduce tumor spread
- (D) Detecting specific tumor markers in samples

Q12. BIO

Under a microscope, plant cells appeared rigid in shape, unlike flexible animal cells. Which structure explains this difference?

- (A) Cell wall
- (B) Vacuole
- (C) Cytoskeleton
- (D) Plasma membrane

Q13. BIO

Which type of joint allows bending of the elbow joint and has a synovial cavity?

- (A) Cartilaginous joint
- (B) Fibrous joint
- (C) Pubic symphysis
- (D) Hinge joint

Q14. BIO

If a round-seeded pea plant is self-fertilized and all of its offspring are also round-seeded:

- (A) Both parents and offspring must be true breed
- (B) Both parents and offspring may be true breed
- (C) Only parents but not offspring will be true breed
- (D) Only offspring but not parents will be true breed

Q15. BIO

A student observes a microorganism under a microscope that lacks a nucleus and is made of a single cell. Which classification fits this organism?

- (A) Unicellular prokaryote
- (B) Unicellular eukaryote
- (C) Multicellular eukaryote
- (D) Multicellular prokaryote

Q16. BIO

In biotechnology, vaccines can be developed by cloning of:

- (A) Gene for antigen of pathogen
- (B) Gene for receptor of the patient
- (C) Gene for antigen of patient
- (D) Gene for antibody of patient

Q17. BIO

Atrioventricular valve closed during which phase of cardiac cycle:

- (A) Ventricular systole
- (B) Ventricular diastole
- (C) Atrial systole
- (D) Atrial diastole

Q18. BIO

If "RRYy" is crossed with "rryy", what will be the ratio of "RRYy" to "rryy" in F₂ generation?

- (A) 9:3:3:1
- (B) 3:1
- (C) 1:3
- (D) 1:1

Q19. BIO

Name the idea of Darwin that best explains the ability of populations to reproduce those individuals who possess beneficial traits.

- (A) Gene flow
- (B) Genetic drift
- (C) Artificial selection
- (D) Natural selection

Q20. BIO

The main function of the pharynx in respiratory system:

- (A) Serves as passage for both food and air
- (B) Produces mucus
- (C) Produces voice
- (D) Filters air

Q21. BIO

At least how many saccharide units must be present in polysaccharide?

- (A) 1
- (B) 2
- (C) 10
- (D) 11

Q22. BIO

A doctor taps below the knee and the leg kicks forward. What does this show?

- (A) conditional response
- (B) Voluntary muscle contractions
- (C) An involuntary reflex to external stimuli
- (D) A delayed response due to brain processing

Q23. BIO

If fertilization does not occur, which part of uterus degenerates?

- (A) Myometrium
- (B) Endometrium
- (C) Perimetrium
- (D) Cervix

Q24. BIO

The main cause of acute kidney failure is:

- (A) Less sweating
- (B) Hypothermia
- (C) Liver failure
- (D) Drinking of excess water

Q25. BIO

Which process uses mRNA to make protein at ribosomes?

- (A) Replication
- (B) Transcription
- (C) Translation
- (D) Cell fractionation

Q26. BIO

Which of the following is the sexually transmitted disease?

- (A) Syphilis
- (B) Lung Cancer
- (C) Tuberculosis
- (D) Autoimmune disorders

Q27. BIO

During diastole, the heart chambers:

- (A) Relax and fill with blood
- (B) Contract strongly
- (C) Eject blood into arteries
- (D) Remain closed

Q28. BIO

The Golgi apparatus is structurally made of a series of flattened membrane-bounded sacs:

- (A) Grana
- (B) Cristae
- (C) Cisternae
- (D) Vesicles

Q29. BIO

Kidneys under the effect of Antidiuretic Hormone (ADH) produce:

- (A) Hypotonic urine with decreased volume
- (B) Hypotonic urine with increased volume
- (C) Hypertonic urine with decreased volume
- (D) Hypertonic urine with increased volume

Q30. BIO

Which type of change is a nerve impulse?

- (A) Electrical and mechanical change
- (B) Chemical and mechanical change
- (C) Electrical and chemical change
- (D) Chemical change only

Q31. BIO

A person has swollen lymph nodes after throat infection. What does this indicate?

- (A) Failure of circulatory system
- (B) Extra glucose storage
- (C) Active immune response
- (D) Blockage of digestive tract

Q32. BIO

Which of the following fluid flows through the lymphatic vessels?

- (A) Plasma
- (B) Lymph
- (C) Bile
- (D) Serum

Q33. BIO

Which one of the following is the most common nitrogenous waste excreted in urine of a healthy human?

- (A) Ammonia
- (B) Urea
- (C) Uric Acid
- (D) Creatinine

Q34. BIO

Hippocampus mainly involved in:

- (A) Vision and hearing reflexes
- (B) Voluntary muscle movement
- (C) Memory storage
- (D) Speech production

Q35. BIO

The covalently bonded non-protein part of enzyme is called:

- (A) Activator
- (B) Prosthetic group
- (C) Coenzyme
- (D) Apoenzyme

Q36. BIO

The outer surface of the axon membrane in a resting neuron is:

- (A) Negative due to sodium ions
- (B) Positive due to sodium ions
- (C) Positive due to potassium ions
- (D) Neutral due to balanced ions

Q37. BIO

Which class of animals excrete ammonia as their primary nitrogenous waste?

- (A) Uricotelic
- (B) Urotelic
- (C) Ammonotelic
- (D) Ureotelic

Q38. BIO

Which of the following best describes the direction of impulse traveling in a typical neuron?

- (A) Axon → dendrite → cell body
- (B) Dendrite → cell body → axon
- (C) Synapse → axon → dendrite
- (D) Cell body → dendrite → axon

Q39. BIO

Homopolysaccharide found in the cell wall of fungi and exoskeleton of arthropods is:

- (A) Cellulose
- (B) Glycogen
- (C) Starch
- (D) Chitin

Q40. BIO

The most abundant lipids in living things are:

- (A) Terpenes
- (B) Waxes
- (C) Steroids
- (D) Acylglycerols

Q41. BIO

Name the type of bond that joins amino acids to form a polypeptide chain:

- (A) Hydrogen bond
- (B) Ionic bond
- (C) Glycosidic bond
- (D) Peptide bond

Q42. BIO

Which of the following is not a globular protein?

- (A) Enzyme
- (B) Hormone
- (C) Channel protein
- (D) Collagen

Q43. BIO

Atrioventricular valve closed during which phase of cardiac cycle:

- (A) Ventricular systole
- (B) Ventricular diastole
- (C) Atrial systole
- (D) Atrial diastole

Q44. BIO

Which specialized cells of liver perform phagocytic function?

- (A) Kupffer cells
- (B) Schwann cells
- (C) Parietal cells
- (D) Chief cells

Q45. BIO

According to Darwin, the main force behind evolution is:

- (A) Migration
- (B) Genetic mutation
- (C) Artificial selection
- (D) Natural selection

Q46. BIO

Beside fertilization, the function of fallopian tube is:

- (A) Nourishment of embryo
- (B) Transport of ovum towards uterus
- (C) Secretion of female hormones
- (D) Implantation of zygote

Q47. BIO

Which property of water allows it to stick to polar surface like wood?

- (A) Density
- (B) Adhesion
- (C) Cohesion
- (D) Non-polar attraction

Q48. BIO

A food sample contains long chains of amino acids bounded together. This indicates the presence of:

- (A) Carbohydrates
- (B) Lipids
- (C) Proteins
- (D) Nucleic acids

Q49. BIO

In which process do cells release energy from oxidation of food molecules?

- (A) Cellular respiration
- (B) Photosynthesis
- (C) DNA replication
- (D) Protein synthesis

Q50. BIO

How many NADH are produced when one Acetyl CoA is oxidized during Krebs's cycle?

- (A) 1
- (B) 3
- (C) 2
- (D) 6

Q51. BIO

Which of the following best describes glycoproteins?

- (A) Proteins linked with carbohydrates
- (B) Proteins linked with DNA
- (C) Proteins linked with lipids
- (D) Proteins linked with minerals

Q52. BIO

The function which is common between Cerebellum and Hippocampus is:

- (A) Equilibrium
- (B) Memory formation
- (C) Body positioning
- (D) Sexual arousal

Q53. BIO

The water content of human kidney is regulated by ADH. Which gland is involved in its secretion?

- (A) Adrenal gland
- (B) Pituitary gland
- (C) Thyroid gland
- (D) Parathyroid gland

Q54. BIO

In males, which of the following is considered a urogenital organ?

- (A) Urethra
- (B) Ureter
- (C) Urinary bladder
- (D) Vas deferens

Q55. BIO

For which reaction, the value of K_c increases with increase in temperature?

- (A) $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- (B) $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
- (C) $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
- (D) $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$

Q56. BIO

The most common type of arthritis is:

- (A) Gout
- (B) Rheumatoid arthritis
- (C) Osteoarthritis
- (D) Spondylitis

Q57. BIO

Overconsumption of which of the following foods increases the risk of calcium oxalate stone?

- (A) Leafy vegetables
- (B) Fruits contain Vitamin C
- (C) Fruits contain high fiber
- (D) Whole grains

Q58. BIO

The other name for interstitial cells in male testes is:

- (A) Leydig cell
- (B) Spermatogonia cell
- (C) Sertoli cell
- (D) Spermatocyte

Q59. BIO

Which product is produced by genetically modified bacteria for patients with Diabetes mellitus?

- (A) Insulin
- (B) Erythropoietin
- (C) Growth hormone
- (D) Vaccine

Q60. BIO

Binding of hemoglobin with oxygen is catalyzed by the enzyme:

- (A) Carbonic anhydrase
- (B) Carboxylase
- (C) Oxygenase
- (D) Dehydrogenase

Q61. BIO

Which changes occur in the endometrium during the proliferative phase of menstrual cycle?

- (A) It begins to shed
- (B) It regenerates and thickens
- (C) It becomes secretory
- (D) No change occurs

Q62. BIO

Transfer of phosphate from one compound to another requires an enzyme called:

- (A) Oxidoreductase
- (B) Transferase
- (C) Hydrolase
- (D) Ligase

Q63. BIO

Linkage of genes in *Drosophila* was first discovered by:

- (A) Thomas Hunt Morgan
- (B) Alfred Sturtevant
- (C) Gregor Mendel
- (D) Hugo de Vries

Q64. BIO

Which of the following structures prevents blood from flowing back into atria?

- (A) Semilunar valves
- (B) Bicuspid & tricuspid valves
- (C) Chordae tendinae
- (D) Papillary muscles

Q65. BIO

Which of the following is a characteristic of a non-competitive enzyme inhibitor?

- (A) Binds to the enzyme active site
- (B) Can be overcome by increasing substrate concentration
- (C) Increases the speed of the reaction
- (D) Point of action is allosteric site

Q66. BIO

The appendix is attached to which part of large intestine?

- (A) Rectum
- (B) Caecum
- (C) Colon
- (D) Ileum

Q67. BIO

If a male with hemophilia marries a non-carrier female, what is the likelihood of their sons inheriting the condition?

- (A) 50%
- (B) 100%
- (C) 0%
- (D) 25%

Q68. BIO

Which of the following is NOT related to DNA?

- (A) Adenine
- (B) Thymine
- (C) Uracil
- (D) Guanine

Q69. BIO

Why Lamarck is being remembered till today?

- (A) Due to his rejected but appealing theory of heredity
- (B) Due to his universally acceptable theory of evolution
- (C) Due to his accepted theory of heredity
- (D) Due to his theory of evolution by natural selection

Q70. BIO

Which of the following neurons conduct impulses from sensory receptors to CNS?

- (A) Sensory neurons
- (B) Motor neurons
- (C) Efferent neurons
- (D) Interneurons

Q71. BIO

Guanine-cytosine pairs enhance DNA stability due to:

- (A) Larger size
- (B) Closer pairing
- (C) More hydrogen bonds
- (D) Double ring structure in both

Q72. BIO

Which of the following substances pass through the glomerulus into Bowman's capsule?

- (A) Glucose
- (B) Red blood cells
- (C) Platelets
- (D) Albumin

Q73. BIO

Shivering thermogenesis involves:

- (A) Voluntary muscle contraction
- (B) Involuntary muscle contraction
- (C) Dehydration
- (D) Hormone secretion

Q74. BIO

The best way to avoid AIDS is:

- (A) Preventive measures
- (B) Vaccination
- (C) Medication
- (D) Shots

Q75. BIO

Which of the following biological molecules releases highest energy from its one gram?

- (A) Carbohydrates
- (B) Lipids
- (C) Protein
- (D) Water

Q76. BIO

Which group of viruses can cause diseases like influenza, measles, and rabies?

- (A) Plant viruses
- (B) Animal viruses
- (C) Fungal viruses
- (D) Bacteriophages

Q77. BIO

If a disease is caused due to a defective gene located on the X chromosome, then the defective gene can only be transmitted to male offspring by the:

- (A) Female gamete
- (B) Male gamete
- (C) Bacteria
- (D) Mutation

Q78. BIO

Which of the following surrounds myofibril in skeletal muscle that stores and distributes calcium ions during muscle functioning?

- (A) Sarcolemma
- (B) Sarcoplasmic reticulum
- (C) Transverse tubules
- (D) Sarcoplasm

Q79. BIO

Water can circulate in living organisms due to:

- (A) Surface tension and polarity
- (B) Cohesion and adhesion
- (C) Solubility in cells
- (D) Stable liquid range

Q80. BIO

What is the chemical composition of chromosomes?

- (A) RNA and lipids
- (B) DNA and proteins
- (C) Carbohydrates and nucleic acids
- (D) Proteins and carbohydrates

Q81. BIO

Which part of small intestine is responsible for nutrient absorption?

- (A) Duodenum
- (B) Jejunum
- (C) Ileum
- (D) Rectum

Q82. BIO

Name the biomolecule essential for information storage and transmission within cells.

- (A) Carbohydrates
- (B) Lipids
- (C) Nucleic acids
- (D) Proteins

Q83. BIO

Which of the following is a route of HIV transmission?

- (A) Unhygienic living conditions
- (B) Blood transfusion with contaminated blood
- (C) Hand shaking
- (D) Living together in the same room

Q84. BIO

Crossing over involves exchange of genetic material between:

- (A) Sister chromatids of same chromosome
- (B) Non-sister chromatids of homologous chromosomes
- (C) Chromatids of non-homologous chromosomes
- (D) Sister chromatids of homologous chromosomes

Q85. BIO

B-lymphocytes are formed and matured in:

- (A) Liver
- (B) Spleen
- (C) Bone marrow
- (D) Thymus

Q86. BIO

Which phenomenon increases the chances of variations?

- (A) Crossing Over
- (B) Linkage
- (C) Epistasis
- (D) Dominance

Q87. BIO

When antibodies produced by B-cells kill the antigens then it is called:

- (A) Cell mediated response
- (B) Passive response
- (C) Humoral response
- (D) Cells collaborated response

Q88. BIO

Automatic and rapid actions that do not involve the conscious part of brain is:

- (A) Reflex actions
- (B) Conditioned reflexes
- (C) Taxes
- (D) Synapses

Q89. BIO

The regulator of muscle contraction, which is released from sarcoplasmic reticulum, is:

- (A) Tropomyosin
- (B) Troponin
- (C) Calcium ions
- (D) ATP

Q90. BIO

Role of mRNA in COVID-19 vaccines like Pfizer and Moderna is to:

- (A) Helps the immune system recognize the virus
- (B) Instructs cells to produce the viral spike protein
- (C) Triggers immediate antibody release from memory cells
- (D) Delivers enzymes that destroy the virus

Q91. BIO

Living cells of cartilage are called as:

- (A) Osteocytes
- (B) Thrombocytes
- (C) Chondrocytes
- (D) Osteoblasts

CHEM SECTION: CHEMISTRY

Questions 92 to 135 (44 MCQs)

Q92. CHEM

Correct order of bond energy will be:

- (A) $\text{HCl} > \text{HBr} > \text{HI}$
 (B) $\text{HBr} > \text{HCl} > \text{HI}$
 (C) $\text{HI} > \text{HCl} > \text{HBr}$
 (D) $\text{HCl} > \text{HI} > \text{HBr}$

Q93. CHEM

IUPAC name of the compound is $\text{CH}_3(\text{CH}_2)_4\text{CH}(\text{CH}_3)_2$:

- (A) 2-methylheptane
 (B) 3-methylheptane
 (C) 4-methylheptane
 (D) Octane

Q94. CHEM

IUPAC name of the compound $\text{C}_2\text{H}_5\text{CH}=\text{C}(\text{C}_3\text{H}_7)\text{C}_2\text{H}_5$ is:

- (A) 1,2-diethyl-2-propylethene
 (B) 3-ethylhept-3-ene
 (C) 4-ethylhept-3-ene
 (D) 4-ethylhept-2-ene

Q95. CHEM

Among the following compounds, the most susceptible to nucleophilic attack on the carbonyl carbon is:

- (A) CH_3COCl
 (B) CH_3CHO
 (C) $\text{CH}_3\text{COOCH}_3$
 (D) $\text{CH}_3\text{COOCOCH}_3$

Q96. CHEM

Which of the following is expected to be the most paramagnetic?

- (A) 3Li
 (B) 4Be
 (C) 5B
 (D) 6C

Q97. CHEM

The formation of activated complex in a reaction is:

- (A) Exothermic process
 (B) Endothermic process
 (C) Either endo or exo
 (D) Always energy released

Q98. CHEM

The maximum probability of finding an electron is at a distance of:

- (A) 0.53 nm
 (B) 0.35 nm
 (C) 0.053 nm
 (D) 0.0053 nm

Q99. CHEM

The IUPAC name of Vinyl acetylene is:

- (A) But-1-en-3-yne
 (B) But-3-en-1-yne
 (C) Pent-3-en-1-yne
 (D) Pent-2-en-4-yne

Q100. CHEM

Which atom has at least single electron in dumbbell shape orbital?

- (A) H
 (B) He
 (C) Li
 (D) B

Q101. CHEM

Which of following adhesive is used to bond broken pieces of jewelry?

- (A) Super glue
 (B) Epoxy resin
 (C) Silicon resin
 (D) Starch

Q102. CHEM

Ratio of sigma bonds and pi bonds present in benzene are:

- (A) 4:1
 (B) 1:4
 (C) 2:3
 (D) 6:1

Q103. CHEM

Which one is addition polymer?

- (A) polyvinyl chloride
 (B) nylon 6,6
 (C) nylon 6,10
 (D) polyester

Q104. CHEM

When one mole of a substance is decomposed preferably as compared to evaporation then decomposition has:

- (A) Low energy
 (B) High energy
 (C) Equal energy
 (D) Cannot be predicted

Q105. CHEM

At start of reaction:

- (A) Average rate is high
 (B) Instantaneous rate is high
 (C) Both rates are same
 (D) Both rates are slow

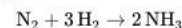
Q106. CHEM

During Clemmensen reduction of aldehyde and ketone, carbonyl group into alkane group is carried out with:

- (A) H_2 and Pd
 (B) LiAlH_4
 (C) Zn/Hg conc. HCl
 (D) $\text{NH}_2\text{-NH}_2$ / KOH

Q107. CHEM

Consider the given reaction:



If 56g of N_2 reacts with 12 g of H_2 and produces 51g of NH_3 , what is the theoretical yield (TY) of NH_3 and the percentage yield (PY) of the reaction? (Molar mass of $\text{N}_2 = 28 \text{ g/mol}$, $\text{H}_2 = 2 \text{ g/mol}$ and $\text{NH}_3 = 17 \text{ g/mol}$)

- (A) TY = 68 g and PY = 75%
 (B) TY = 34 g and PY = 67%
 (C) TY = 68 g and PY = 33%
 (D) TY = 34 g and PY = 75%

Q108. CHEM

When SHE is connected with Cu electrode using salt bridge and external wire:

- (A) Cu reduces
 (B) Cu^{+2} reduces
 (C) H⁺ reduces
 (D) H_2 reduces

Q109. CHEM

The ionic compound among the following with the highest lattice energy is:

- (A) LiF
- (B) NaCl
- (C) KCl
- (D) CsI

Q110. CHEM

Digestion of protein started when food enters in:

- (A) Mouth
- (B) Stomach
- (C) Intestine
- (D) Epiglottis

Q111. CHEM

Which compound will not show geometrical isomerism?

- (A) But-2-ene
- (B) 1,2-dimethylcyclopropane
- (C) Pent-1-ene
- (D) 1,3-dimethylcyclopentane

Q112. CHEM

Which of the following is least volatile?

- (A) Glycerol
- (B) Water
- (C) Acetic acid
- (D) Diethyl ether

Q113. CHEM

All of following have two bond pairs and show linear geometry except:

- (A) SnCl₂
- (B) CS₂
- (C) HCN
- (D) CO₂

Q114. CHEM

Which of the following molecules have similar molecular shape?

- (A) NH₃ & AlCl₃
- (B) BCl₃ & NH₃
- (C) AlCl₃ and PCl₃
- (D) H₂O & SnCl₂

Q115. CHEM

Value of electronegativity of atoms A and B are 1.20 and 4.0 respectively, the percent ionic character will be:

- (A) 43%
- (B) 50%
- (C) 55%
- (D) 73%

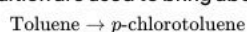
Q116. CHEM

Phenol differs from ethanol because it:

- (A) Forms stronger hydrogen bonds to its aromatic ring
- (B) Is more acidic because of resonance stabilized conjugate base
- (C) Readily undergoes nucleophilic substitution at the -OH group
- (D) Is completely insoluble in water due to its benzene ring

Q117. CHEM

Which reagent and condition are used to bring about the reaction shown?



- (A) Cl₂ in the dark
- (B) Cl₂ in the presence of AlCl₃
- (C) Cl₂ in the presence of UV light
- (D) Concentrated HCl heated under reflux

Q118. CHEM

What is the percentage yield when actual yield and theoretical yield are 2g and 4g respectively?

- (A) 25%
- (B) 50%
- (C) 75%
- (D) 85%

Q119. CHEM

IUPAC name of CH₃CH₂Cl is:

- (A) Chloroethane
- (B) Chloroethyne
- (C) Chloroethene
- (D) Ethyl chloride

Q120. CHEM

The order of reactivity of following R-X for SN₂ reaction is:

- (A) RI > RBr > RCl > RF
- (B) RBr > RF > RCl > RI
- (C) RCl > RF > RBr > RI
- (D) RF > RBr > RCl > RI

Q121. CHEM

Which is not true about benzene:

- (A) Sp² hybridization
- (B) Fractional bond order
- (C) No elimination reaction
- (D) 6 sites for monosubstitution

Q122. CHEM

If ionization energy of an element is greater then:

- (A) More is its reducing power
- (B) More is its electropositivity
- (C) Less is its metallic character
- (D) More is its atomic radius

Q123. CHEM

The mass of hydrogen gas needed to produce 51g ammonia is:

- (A) 6 g
- (B) 9 g
- (C) 12 g
- (D) 15 g

Q124. CHEM

Select the standard condition for temperature and pressure:

- (A) 1 atm and 0 K
- (B) 760 torr and 25°C
- (C) 2 bar and 25°C
- (D) 14.7 psi and 0°C

Q125. CHEM

Which of the following is NOT a state function?

- (A) Enthalpy
- (B) Work
- (C) Internal energy
- (D) Pressure

Q126. CHEM

Which one is not a type of stereoisomerism?

- (A) Conformational isomerism
- (B) Optical isomerism
- (C) Geometrical isomerism
- (D) Metamerism

Q127. CHEM

Formic acid reacts with ethanol in presence of acid catalyst producing:

- (A) Ester
- (B) Ether
- (C) Acid anhydride
- (D) Phenol

Q128. CHEM

K is called specific rate constant because it is:

- (A) Rate per unit concentration
- (B) Temperature independent
- (C) Depends on concentration
- (D) Unitless

Q129. CHEM

Number of sigma bonds in methyl chloride due to sp^3-s overlap is/are:

- (A) 1
- (B) 2
- (C) 3
- (D) 4

Q130. CHEM

When pressure is 1520 torr then density of oxygen gas will be:

- (A) $64/RT$
- (B) $32/RT$
- (C) $16/RT$
- (D) $128/RT$

Q131. CHEM

Which equation is used to calculate concentration for n mole of an ideal gas?

- (A) PV/RT
- (B) P/RT
- (C) PCM/RT
- (D) PM/RT

Q132. CHEM

Which carbonyl carbon is more electrophilic?

- (A) $HCOOH$
- (B) $HCHO$
- (C) CH_3COCH_3
- (D) CH_3COOH

Q133. CHEM

50g of Mg is burnt with 32g of oxygen to form MgO , amount of excess reagent left is?

- (A) 6g Mg
- (B) 2g Mg
- (C) 8g O_2
- (D) 16g O_2

Q134. CHEM

The heat of formation of CO and CO_2 are -26.4 Kcal and -94.0 Kcal respectively. The heat of combustion of carbon monoxide according to Hess's Law will be:

- (A) $+26.4$ Kcal
- (B) -67.6 Kcal
- (C) $+94.0$ Kcal
- (D) -120.4 Kcal

Q135. CHEM

Rate of dehydration of alcohol is:

- (A) $3^\circ > 2^\circ > 1^\circ$
- (B) $1^\circ > 3^\circ > 2^\circ$
- (C) $2^\circ > 3^\circ > 1^\circ$
- (D) $3^\circ > 1^\circ > 2^\circ$

PHY SECTION: PHYSICS

Questions 136 to 171 (36 MCQs)

Q136. PHY

During the drilling of a metal surface the drill bit heats up. This heat comes from the:

- (A) Vibration of the tool
- (B) Work done against friction
- (C) Flow of electric current
- (D) Compression of air

Q137. PHY

If 2J of work is done in moving two coulombs of charge from one point to the other in an electric field. The potential difference between the points is:

- (A) 1J/C
- (B) 2J/C
- (C) 2JC
- (D) 4J/C

Q138. PHY

The motion of transverse waves involves particle's vibration:

- (A) Along the wave direction
- (B) Opposition to energy flow
- (C) Perpendicular to wave propagation
- (D) In random direction at every point

Q139. PHY

A body moving in a circle, half revolution in terms of radians is equivalent:

- (A) π
- (B) $\pi/6$
- (C) $\pi/2$
- (D) 2π

Q140. PHY

If $A = (a\mathbf{i} + b\mathbf{j})$ and $B = 4(a\mathbf{i} - b\mathbf{j})$, magnitude of $A \times B =$

- (A) $4(a^2 + b^2)$
- (B) $8ab$
- (C) $8(a+b)$
- (D) 0

Q141. PHY

A proton and an alpha particle enter a uniform magnetic field of the same magnitude perpendicular to the direction of the field with equal speeds. Compared to the proton, the alpha particle's path will have:

- (A) Larger radius
- (B) Smaller radius
- (C) Smaller path length
- (D) Greater deflection

Q142. PHY

In circular motion, if angular displacement is kept constant, decreasing the radius will:

- (A) Increase linear displacement
- (B) Increase linear velocity
- (C) Decrease linear displacement
- (D) Not affect linear displacement

Q143. PHY

When force and displacement are in opposite direction then the work done is said to be:

- (A) Positive
- (B) Negative
- (C) Infinite
- (D) Maximum

Q144. PHY

In a step-up transformer, if the secondary voltage is increased by a factor of 10, the current in secondary coil will be:

- (A) 10 times higher than the primary current
- (B) 10 times lower than the primary current
- (C) Equal to the primary current
- (D) One-tenth of the primary current

Q145. PHY

When a droplet reaches terminal velocity, its acceleration is:

- (A) Zero
- (B) Variable
- (C) Not changed
- (D) Negative

Q146. PHY

Newton's original formula underestimated speed of sound in air because he:

- (A) Ignored viscosity
- (B) Assumed isothermal
- (C) Considered vacuum conditions
- (D) Assumed adiabatic

Q147. PHY

The point where the electric field is zero between two opposite charge lies:

- (A) Closer to the positive charge
- (B) At the mid-point
- (C) Closer to the negative charge
- (D) Nowhere between them

Q148. PHY

Consider these two vectors $A = 2\mathbf{i} + 3\mathbf{j}$ and $B = -6\mathbf{i} + 4\mathbf{j}$. The angle between these two vectors is:

- (A) 0°
- (B) 90°
- (C) 120°
- (D) 180°

Q149. PHY

A displacement time graph is a straight line inclined up at angle of 45° with X-axis, velocity of body according to this graph is:

- (A) Increasing
- (B) Decreasing
- (C) Constant
- (D) Decreasing at start and then may decrease

Q150. PHY

A 150 kg car has its velocity reduced from 20 m/s to 10 m/s in 3.0 sec. How large was the average retarding force?

- (A) 500 N
- (B) 2500 N
- (C) 1500 N
- (D) 1000 N

Q151. PHY

Internal resistance reduces the terminal voltage because it:

- (A) Produces back emf
- (B) Causes power loss inside the battery
- (C) Increases the current
- (D) Decreases the emf

Q152. PHY

The force between two charges is 28 N in vacuum. If paraffin wax of relative permittivity 2.8 is introduced between the charges, then the force reduces to:

- (A) 25 N
- (B) 20 N
- (C) 15 N
- (D) 10 N

Q153. PHY

A body moves along a semicircular path of radius 10 m from one end of the diameter to the other. The ratio of distance to displacement is:

- (A) $\pi : 1$
- (B) $1 : \pi$
- (C) $\pi : 2$
- (D) $2 : \pi$

Q154. PHY

A body is projected with speed v at angle θ and covers horizontal range R . If speed is doubled, the new range will be:

- (A) $R/2$
- (B) R
- (C) $2R$
- (D) $4R$

Q155. PHY

A ball of mass m strikes a wall and rebounds with the same speed in the opposite direction. The change in momentum is:

- (A) 0
- (B) mv
- (C) $-2mv$
- (D) $-mv$

Q156. PHY

The angle formed at the center of a circle as a body moves from one position to another is:

- (A) Angular displacement
- (B) Angular velocity
- (C) Angular acceleration
- (D) Angular momentum

Q157. PHY

In laminar flow of fluid, its adjacent layers:

- (A) Resist each other
- (B) Mix with each other
- (C) Slide smoothly past each other
- (D) Produce turbulence

Q158. PHY

A point lies 3 m from $+5 \mu\text{C}$ and 4 m from $-3 \mu\text{C}$. The direction of net electric field is:

- (A) Away from $+5 \mu\text{C}$
- (B) Towards $+5 \mu\text{C}$
- (C) Away from $-3 \mu\text{C}$
- (D) Perpendicular to the line joining

Q159. PHY

The increase in kinetic energy associated with decreased pressure of a fluid in a horizontal pipe is a consequence of the:

- (A) Bernoulli's Principle
- (B) Equation of continuity
- (C) Pascal's principle
- (D) Torricelli's theorem

Q160. PHY

An electron is projected along the positive x -axis in a magnetic field lying in the xz -plane. The magnetic force on the electron acts along the:

- (A) x -axis
- (B) $-x$ -axis
- (C) y -axis
- (D) $-y$ -axis

Q161. PHY

The magnetic flux through a 1 m^2 loop in 0.5 T field is same as through 0.5 m^2 in what field?

- (A) 1.0 T at 0°
- (B) 1.0 T at 60°
- (C) 2.0 T at 90°
- (D) 0.5 T at 90°

Q162. PHY

A 10 kg body falling through viscous medium reaches terminal velocity. The net force on body is:

- (A) 0 N
- (B) 9.8 N
- (C) 98 N
- (D) 980 N

Q163. PHY

The temperature coefficient of a conductor is zero. This means resistance:

- (A) Increases
- (B) Decreases
- (C) Remains same
- (D) Becomes zero

Q164. PHY

The path difference between two sound waves = 100 cm ; wavelength = 50 cm . The waves produce:

- (A) Beats
- (B) Echo
- (C) Loudness
- (D) Silence

Q165. PHY

Potential energy decreases during:

- (A) Compressing a spring
- (B) Stretching a spring
- (C) Releasing a stretched spring
- (D) Holding spring at maximum extension

Q166. PHY

A diver of mass m at depth h below sea level. Gravitational potential energy is:

- (A) 0
- (B) mgh
- (C) $-mgh$
- (D) $2mgh$

Q167. PHY

A constant force F acts on a body and displaces it by Δd in time Δt . The rate at which work is done is:

- (A) $F \times \Delta d$
- (B) $F \times \Delta t$
- (C) $F \times \Delta d / \Delta t$
- (D) $F \times \Delta t / \Delta d$

Q168. PHY

For vectors $A = 2i + 3j$ and $B = -6i + 4j$, the angle between them is:

- (A) 0°
- (B) 90°
- (C) 120°
- (D) 180°

Q169. PHY

The phenomenon of interference of sound waves requires:

- (A) Two sources with different frequencies
- (B) Two coherent sources
- (C) A single source
- (D) A single source and a reflecting surface

Q170. PHY

A gas expands from 1 m^3 to 3 m^3 at constant pressure of 2 Pa . Work done is:

- (A) 2 J
- (B) 4 J
- (C) 6 J
- (D) 8 J

Q171. PHY

If frequency of AC is doubled, the inductive reactance will:

- (A) Remain same
- (B) Be halved
- (C) Be doubled
- (D) Become zero

LOGIC SECTION: LOGICAL REASONING

Questions 172 to 180 (9 MCQs)

Q172. LOGIC

Statements:

All melons are apples.

No apples are mangoes.

Conclusions:

I. All melons are mangoes.

II. Apples are not mangoes.

- (A) All melons are mangoes
 (B) Apples are not mangoes
 (C) Both A and B are correct
 (D) None of them

Q173. LOGIC

If Amna is older than Muneeb, and Muneeb is younger than Jaffar, then Amna is:

- (A) Older than Jaffar
 (B) Younger than Jaffar
 (C) Same age as Jaffar
 (D) Not enough information to say

Q174. LOGIC

In a family of six members:

• P is the father of Q

• R is the mother of Q

• S is the sister of Q

• T is the brother of P

Who is the uncle of Q?

- (A) P
 (B) R
 (C) S
 (D) T

Q175. LOGIC

If A is the mother of B and C is the child of B, then what is the relationship between A and C?

- (A) Aunt
 (B) Grandmother
 (C) Sister
 (D) Cousin

Q176. LOGIC

Which number comes in the missing place?

120, 119, 117, 114, 110, ___

- (A) 105
 (B) 100
 (C) 95
 (D) 107

Q177. LOGIC

A spying agent coded POWER as QPXFS. Using this pattern, what will be the code for GUNBD?

- (A) HVPFE
 (B) HVOCE
 (C) HVNDE
 (D) HVODE

Q178. LOGIC

A new virus is spreading rapidly in the city. The government should impose temporary travel restrictions. What is true about this course of action?

- (A) Travel restrictions help control the virus spread.
 (B) The government should promote travel to support the economy.
 (C) Travel restrictions do not affect virus transmission.
 (D) People should disregard government advice.

Q179. LOGIC

A tank can hold 240 L of water. Currently, water is filled to one-third of its capacity. How much more water can it hold?

- (A) 60 L
 (B) 80 L
 (C) 100 L
 (D) 160 L

Q180. LOGIC

M, N, P, Q, S, ??

- (A) T
 (B) U
 (C) V
 (D) W

OFFICIAL VERIFIED ANSWER KEY

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Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB
1	B	ENG	37	C	BIO	73	B	BIO	109	A	CHEM	145	A	PHY
2	B	ENG	38	B	BIO	74	A	BIO	110	B	CHEM	146	B	PHY
3	A	ENG	39	D	BIO	75	B	BIO	111	C	CHEM	147	D	PHY
4	A	ENG	40	D	BIO	76	B	BIO	112	A	CHEM	148	B	PHY
5	A	ENG	41	D	BIO	77	A	BIO	113	A	CHEM	149	C	PHY
6	C	ENG	42	D	BIO	78	B	BIO	114	D	CHEM	150	A	PHY
7	D	ENG	43	A	BIO	79	B	BIO	115	D	CHEM	151	B	PHY
8	D	ENG	44	A	BIO	80	B	BIO	116	B	CHEM	152	D	PHY
9	A	ENG	45	D	BIO	81	B	BIO	117	B	CHEM	153	C	PHY
10	C	BIO	46	B	BIO	82	C	BIO	118	B	CHEM	154	D	PHY
11	D	BIO	47	B	BIO	83	B	BIO	119	B	CHEM	155	C	PHY
12	A	BIO	48	C	BIO	84	B	BIO	120	A	CHEM	156	A	PHY
13	D	BIO	49	A	BIO	85	C	BIO	121	D	CHEM	157	C	PHY
14	A	BIO	50	B	BIO	86	A	BIO	122	C	CHEM	158	A	PHY
15	A	BIO	51	A	BIO	87	C	BIO	123	B	CHEM	159	A	PHY
16	A	BIO	52	B	BIO	88	A	BIO	124	D	CHEM	160	C	PHY
17	A	BIO	53	B	BIO	89	C	BIO	125	B	CHEM	161	A	PHY
18	D	BIO	54	A	BIO	90	B	BIO	126	D	CHEM	162	A	PHY
19	D	BIO	55	D	BIO	91	C	BIO	127	A	CHEM	163	C	PHY
20	A	BIO	56	C	BIO	92	A	CHEM	128	A	CHEM	164	C	PHY
21	D	BIO	57	A	BIO	93	A	CHEM	129	C	CHEM	165	C	PHY
22	C	BIO	58	A	BIO	94	C	CHEM	130	A	CHEM	166	C	PHY
23	B	BIO	59	A	BIO	95	A	CHEM	131	B	CHEM	167	C	PHY
24	C	BIO	60	A	BIO	96	D	CHEM	132	B	CHEM	168	B	PHY
25	C	BIO	61	B	BIO	97	B	CHEM	133	B	CHEM	169	B	PHY
26	A	BIO	62	B	BIO	98	C	CHEM	134	B	CHEM	170	B	PHY
27	A	BIO	63	A	BIO	99	A	CHEM	135	A	CHEM	171	C	PHY
28	C	BIO	64	B	BIO	100	D	CHEM	136	B	PHY	172	B	LOGIC
29	C	BIO	65	D	BIO	101	A	CHEM	137	A	PHY	173	D	LOGIC
30	C	BIO	66	B	BIO	102	A	CHEM	138	C	PHY	174	D	LOGIC
31	C	BIO	67	C	BIO	103	A	CHEM	139	A	PHY	175	B	LOGIC
32	B	BIO	68	C	BIO	104	A	CHEM	140	B	PHY	176	A	LOGIC
33	B	BIO	69	A	BIO	105	B	CHEM	141	A	PHY	177	B	LOGIC
34	C	BIO	70	A	BIO	106	C	CHEM	142	C	PHY	178	A	LOGIC
35	B	BIO	71	C	BIO	107	A	CHEM	143	B	PHY	179	D	LOGIC
36	B	BIO	72	A	BIO	108	B	CHEM	144	D	PHY	180	A	LOGIC

SUBJECT-WISE PERFORMANCE BREAKDOWN

SUBJECT	MAX	YOUR SCORE	ACCURACY
English	9		----- %
Biology	82		----- %
Chemistry	44		----- %
Physics	36		----- %
Logical Reasoning	9		----- %
TOTAL	180	-----	----- %

PMDC PROVINCIAL MERIT FORMULA

Official Weightage Law:

- MDCAT Component (50%): (Your Score / 180) × 50
- FSc / HSSC Component (40%): (FSc Marks / 1100) × 40
- Matric / SSC Component (10%): (Matric Marks / 1100) × 10

Estimated Provincial Merit Aggregate: ----- %

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1

Key: (B)

ENGLISH

05. Active-Passive Voice, Reported Speech & Syntax

He said, "Will you listen to such a man?" Choose the most appropriate indirect speech:

CORE CONCEPT & DERIVATION

In indirect speech for closed (yes/no) questions, the reporting verb is changed to 'asked' or 'inquired', the conjunction 'whether' or 'if' introduces the reported clause, and the modal auxiliary verb backshifts accordingly.

Formula / Rule / Reaction:

Direct: Said, "Will + subject + verb..." → Indirect: Asked + whether/if + subject + would + verb...

Solution:

- The direct question begins with the auxiliary 'Will', requiring 'whether' or 'if' as the linking conjunction rather than 'that'.
- The future modal 'will' backshifts to past modal 'would' because the reporting verb 'said' is in the past tense.
- The interrogative word order reverts to assertive word order (subject before verb: 'they would listen'). Therefore, Option B is correct.

Why other options are incorrect:

- Option A:** Uses 'that' before the reported clause, which is grammatically incorrect for interrogative reported structures.
- Option C:** Retains the present modal 'will' without mandatory backshifting to 'would' and uses 'told' without an indirect object.
- Option D:** Converts an interrogative inquiry into an imperative command ('asked them to listen'), fundamentally altering the original meaning.

Question #2

Key: (B)

ENGLISH

01. Vocabulary, Synonyms, Antonyms & Spelling

"His lachrymose speech at the funeral moved everyone to tears." Choose the synonym for lachrymo...

CORE CONCEPT & DERIVATION

Vocabulary in context requires matching the semantic meaning and emotional tone of the underlined formal adjective.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The adjective 'lachrymose' originates from the Latin 'lacrimosus' (from 'lacrima', meaning tear).
- It denotes being tearful, sorrowful, or tending to cause tears. In the context of a funeral moving listeners to tears, 'weepy' serves as the direct synonym.

Why other options are incorrect:

- Option A:** 'Joyful' means expressing great happiness, which is an antonym.
- Option C:** 'Monotonous' means dull, tedious, and repetitious, lacking variety rather than expressing sadness.
- Option D:** 'Humorous' means funny or comical, directly opposing the somber nature of a funeral speech.

Question #3

Key: (A)

ENGLISH

02. Idioms, Phrasal Verbs & Literary Figures

Identify the simile:

CORE CONCEPT & DERIVATION

A simile is a figure of speech that explicitly compares two distinct entities using connective words such as 'like' or 'as'.

Formula / Rule / Reaction:

Simile = Explicit comparison using 'like' or 'as'
Metaphor = Implicit direct identification without 'like' or 'as'

Solution:

- Option A directly compares her trembling to the movement of a wind-blown leaf using the explicit connective preposition 'like'.

Why other options are incorrect:

- Option B:** States directly that she 'was a statue', which is a metaphor.
- Option C:** States that she 'was drowning in doubt', asserting an implied figurative comparison (metaphor).
- Option D:** Equates her thoughts directly to 'a whirlwind', functioning as a metaphor.

Question #4

Key: (A)

ENGLISH

05. Active-Passive Voice, Reported Speech & Syntax

The board will approve the budget only after the auditor verifies the accounts. The most approp...

CORE CONCEPT & DERIVATION

In complex sentences containing both a main clause and a subordinate time clause, both clauses undergo voice transformation while strictly preserving their respective grammatical tenses.

Formula / Rule / Reaction:

Active: Subject + will + V₁ + Object → Passive: Object + will be + V₃ + by Subject
Active: Subject + V₁(s/es) + Object → Passive: Object + is/are + V₃ + by Subject

Solution:

- Main clause: 'The board will approve the budget' transforms to 'The budget will be approved by the board'.
- Subordinate clause: 'after the auditor verifies the accounts' (present simple) transforms to 'after the accounts are verified by the auditor'. Combining both yields Option A.

Why other options are incorrect:

- Option B:** Changes the future tense of the main clause to present simple ('is approved') and shifts the subordinate clause to present perfect.
- Option C:** Distorts the main clause into present continuous ('is being approved'), altering the intended future aspect.
- Option D:** Shifts the main clause into present perfect ('has been approved') and the subordinate clause into past simple ('were verified').

Question #5

Key: (A)

ENGLISH

05. Active–Passive Voice, Reported Speech & Syntax

He does his work without any care . The underlined part of the sentence is an:

CORE CONCEPT & DERIVATION

A prepositional phrase functions as an adverb phrase when it modifies a verb, adjective, or another adverb by indicating manner, place, time, or degree.

Formula / Rule / Reaction:

Verb + Prepositional phrase answering 'How?' = Adverb Phrase of Manner

Solution:

- The phrase 'without any care' begins with the preposition 'without' and answers the question 'How does he do his work?'.
- Because it modifies the predicate verb 'does' by describing the manner of action, it functions as an adverb phrase.

Why other options are incorrect:

- Option B:** An adjective phrase must modify a noun or pronoun; here, the phrase modifies the action verb rather than the noun 'work'.
- Option C:** A noun phrase functions as a subject, direct object, or complement; this phrase functions adverbially.
- Option D:** An appositive phrase renames or explains an immediately adjacent noun or pronoun, which is not the case here.

Question #6

Key: (C)

ENGLISH

02. Idioms, Phrasal Verbs & Literary Figures

The purpose of using exaggerated language in parody is:

CORE CONCEPT & DERIVATION

Parody is an artistic or literary composition that imitates the distinctive style of a specific author, genre, or work to achieve a comical effect.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Parody employs hyperbole (exaggeration) to blow typical mannerisms, stylistic choices, or motifs out of proportion.
- The primary functional objective of hyperbole in parody is to entertain an audience by mocking and satirizing the subject matter.

Why other options are incorrect:

- Option A:** Parody subverts solemnity; it deliberately breaks down a serious tone.
- Option B:** Broad criticism of societal norms is primarily the function of broad social satire, whereas parody targets stylistic imitation for ridicule.
- Option D:** Exaggeration highlights obvious features to make them recognizable, not to confuse the reader.

Question #7

Key: (D)

ENGLISH

06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence:

CORE CONCEPT & DERIVATION

Parallelism requires that coordinate items linked by coordinating conjunctions in a series share identical grammatical forms.

Formula / Rule / Reaction:

Subject + Verb + to[V₁, V₁, and V₁]

Solution:

- The verb 'aims' takes an infinitive complement ('to reduce').
- When multiple verbs share the marker 'to', the subsequent coordinate verbs must consistently appear as bare infinitives ('reduce', 'promote', and 'create'). Option D maintains complete parallelism.

Why other options are incorrect:

- Option A:** Ungrammatically mixes 'aims at reduce' (preposition plus base verb), an infinitive ('to promote'), and a gerund ('creating').
- Option B:** Combines 'to reducing' with 'create', violating idiomatic complementation and parallelism.
- Option C:** Combines two infinitives ('to reduce', 'to promote') with an uncoordinated gerund-participle ('creating').

Question #8

Key: (D)

ENGLISH

01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the word with incorrect spelling:

CORE CONCEPT & DERIVATION

Identification of orthographic correctness based on standard English lexical conventions.

Formula / Rule / Reaction:

Incorrect: Pregmetic → Correct: Pragmatic

Solution:

- The word 'pragmatic' derives from the Greek root 'pragma' (meaning deed or matter).
- The spelling 'Pregmetic' substitutes the vowel 'a' with 'e' in both internal syllables, making it orthographically incorrect.

Why other options are incorrect:

- Option A:** 'Immigrant' is spelled correctly with double 'm' and ending in 'ant'.
- Option B:** 'Ancestors' is spelled correctly with 'c' and 'or'.
- Option C:** 'Montessori' is correctly spelled with double 's'.

Question #9 Key: (A)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Choose the sentence in which "only" indicates that Jamila was the only person who spoke about h...

CORE CONCEPT & DERIVATION

The placement of limiting modifiers such as 'only' dictates semantic scope; a limiting modifier must be placed directly adjacent to the word or constituent it restricts.

Formula / Rule / Reaction:

Only + Noun (Jamila) = Exclusivity applies strictly to the person speaking

Solution:

- To restrict the action of speaking exclusively to Jamila (meaning no other person stated this), 'only' must precede the proper noun 'Jamila'.
- Therefore, 'Only Jamila said she was tired' denotes that she was the solitary individual who made that statement.

Why other options are incorrect:

- Option B:** 'Jamila only said...' implies she merely said it, as opposed to writing it or taking action.
- Option C:** 'Jamila said only she...' denotes that in Jamila's view, she was the single individual experiencing fatigue.
- Option D:** 'Jamila said she was only tired' means she was merely tired and nothing more (such as sick or injured).

Question #10 Key: (C)BIOLOGY
08. Immunity

A person has swollen lymph nodes after throat infection. What does this indicate?

CORE CONCEPT & DERIVATION

Lymph nodes act as biological filters containing high concentrations of lymphocytes and macrophages that activate and proliferate during localized infections.

Formula / Rule / Reaction:

Pathogen entry → Antigen presentation in regional nodes → Lymphocyte proliferation → Lymphadenopathy

Solution:

- During an upper respiratory or pharyngeal infection, foreign pathogens drain via afferent lymphatic vessels into cervical lymph nodes.
- B and T lymphocytes within germinal centers rapidly proliferate and macrophages phagocytose cellular debris, causing temporary nodal enlargement (reactive lymphadenitis).
- This enlargement directly indicates an active, effective immune response.

Why other options are incorrect:

- Option A:** Circulatory system failure manifests as systemic edema, hypoperfusion, or cardiogenic shock, not localized cervical lymphadenopathy.
- Option B:** Excess glucose is converted into glycogen in the liver and skeletal muscle, not stored in lymphatic tissue.
- Option D:** Blockage of the digestive tract presents with acute abdominal pain, vomiting, and constipation.

Question #11 Key: (D)BIOLOGY
17. Biotechnology

Monoclonal antibodies are useful in cancer diagnosis by:

CORE CONCEPT & DERIVATION

Monoclonal antibodies (mAbs) are monospecific immunoglobulins derived from a single hybridoma clone that bind with high affinity to a specific epitope on an antigen.

Formula / Rule / Reaction:

mAb + Tumor-Specific Antigen (Epitope) → Specific Antigen-Antibody Complex (Detection)

Solution:

- Malignant neoplastic cells frequently express distinctive cell-surface proteins or overexpress specific glycoproteins (tumor markers).
- Engineered monoclonal antibodies coupled with diagnostic fluorophores, radioisotopes, or enzymatic tags selectively bind these tumor antigens in tissue biopsies and serum, allowing precise diagnosis.

Why other options are incorrect:

- Option A:** Monoclonal antibodies are diagnostic or therapeutic targeting proteins, not cellular scaffolds that regenerate or replace structural tissues.
- Option B:** Gene editing tools (such as CRISPR-Cas9), not antibodies, alter the nucleotide sequence of genomic DNA.
- Option C:** Destroying healthy tissues is a toxic adverse event of non-selective therapies, contradicting clinical intent.

Question #12 Key: (A)BIOLOGY
01. Cell

Under a microscope, plant cells appeared rigid in shape, unlike flexible animal cells. Which st...

CORE CONCEPT & DERIVATION

The primary morphological distinction between plant and animal cells regarding structural rigidity is the presence of an extracellular wall.

Formula / Rule / Reaction:

Cell Wall Composition: Cellulose microfibrils + Hemicellulose + Pectin → Rigid structural box

Solution:

- Plant cells possess a robust, non-living cell wall external to the plasma membrane that withstands substantial turgor pressure without bursting.
- Animal cells lack a cell wall and are enclosed solely by a fluid phospholipid bilayer, rendering them pliable and flexible in shape.

Why other options are incorrect:

- Option B:** The central vacuole maintains turgor pressure against the wall, but does not provide fixed mechanical rigidity by itself.
- Option C:** The cytoskeleton (microfilaments, microtubules, intermediate filaments) is present in both animal and plant cells and allows cell flexibility.
- Option D:** The plasma membrane is a fluid mosaic structure present in both kingdoms and cannot confer rigid fixed geometry on its own.

Question #13 Key: (D)BIOLOGY
11. Support & Movement

Which type of joint allows bending of the elbow joint and has a synovial cavity?

CORE CONCEPT & DERIVATION

Synovial joints are classified morphologically by the shapes of their articulating surfaces and the functional axes of movement permitted.

Formula / Rule / Reaction:

Hinge Joint (Ginglymus) = Uniaxial articulation allowing flexion and extension in a single sagittal plane

Solution:

- The humeroulnar articulation of the elbow joint is enclosed within a joint capsule containing a synovial cavity lined with synovial membrane.
- It functions mechanically as a hinge joint, permitting movement strictly along one axis (flexion and extension).

Why other options are incorrect:

- Option A:** Cartilaginous joints lack a synovial fluid cavity; articulating bones are joined directly by hyaline or fibrocartilage.
- Option B:** Fibrous joints (such as cranial sutures) are held tightly by dense collagen fibers, possess no cavity, and allow virtually no movement.
- Option C:** The pubic symphysis is a secondary cartilaginous (amphiarthrodial) joint, lacking a synovial cavity and hinge mobility.

Question #14 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

If a round-seeded pea plant is self-fertilized and all of its offspring are also round-seeded:

CORE CONCEPT & DERIVATION

In Mendelian genetics, an organism is true-breeding (homozygous) for a phenotypic trait if repeated self-fertilization produces identical progeny exclusively.

Formula / Rule / Reaction:If parent is Rr (heterozygous): $Rr \times Rr \rightarrow 1 RR : 2 Rr : 1 rr$ (25% wrinkled)If parent is RR (homozygous): $RR \times RR \rightarrow 100\% RR$ (100% round)**Solution:**

- Round seed coat phenotype is governed by the dominant allele (R), while wrinkled is recessive (r).
- If the parent were heterozygous (Rr), selfing would generate wrinkled seeds in a 3:1 ratio. Because 100% of offspring are round, the parent must be homozygous (RR).
- All offspring inherit exclusively R alleles, making every offspring RR (true-breeding). Thus, both parent and offspring must be true-breeding.

Why other options are incorrect:

- Option B:** 'May be' is scientifically imprecise; under Mendelian genetics, 100% round progeny upon selfing guarantees true-breeding status.
- Option C:** Offspring inheriting genes strictly from an RR parent cannot become heterozygous.
- Option D:** Offspring cannot be true-breeding if the parent is genetically mixed and generates segregating gametes.

Question #15 Key: (A)BIOLOGY
01. Cell

A student observes a microorganism under a microscope that lacks a nucleus and is made of a sin...

CORE CONCEPT & DERIVATION

The fundamental cellular distinction rests on cellularity (single-celled vs. multicellular) and nuclear compartmentalization (prokaryotic vs. eukaryotic).

Formula / Rule / Reaction:

Unicellular + No membrane-bound nucleus = Prokaryote (Domain Bacteria or Archaea)

Solution:

- The organism consists of a single independent physiological cell, defining it as unicellular.
- The absolute absence of a membrane-delimited true nucleus defines it unambiguously as a prokaryote.

Why other options are incorrect:

- Option B:** Eukaryotes possess a distinct, double membrane-bound nucleus housing genomic DNA.
- Option C:** Multicellular eukaryotes (e.g., fungi, animals, plants) possess both multiple coordinated cells and distinct nuclei.
- Option D:** Prokaryotes do not form complex multicellular tissue architectures with cell differentiation.

Question #16 Key: (A)BIOLOGY
17. Biotechnology

In biotechnology, vaccines can be developed by cloning of:

CORE CONCEPT & DERIVATION

Recombinant subunit vaccines are produced by inserting the gene encoding an immunogenic surface protein of a pathogenic organism into an expression vector.

Formula / Rule / Reaction:Isolation of viral/bacterial antigen gene $\xrightarrow{\text{Cloning}}$ Expression in host (e.g., yeast) $\rightarrow$ Purified recombinant anti**Solution:**

- The immune system generates memory B and T cells against foreign antigenic epitopes.
- Cloning the pathogen's antigen gene allows harmless in vitro expression of the antigen (e.g., Hepatitis B surface antigen), which stimulates active immunity upon injection without infection risk.

Why other options are incorrect:

- Option B:** Cloning host cell receptors does not present a foreign microbial antigen to prime acquired immunity.
- Option C:** Patient self-antigens would trigger dangerous autoimmune reactions if targeted.
- Option D:** Transfer of antibodies provides short-lived passive immunity, whereas active vaccination requires antigen exposure.

Question #17 Key: (A)BIOLOGY
Q7. Circulation / Transport

Atrioventricular valve closed during which phase of cardiac cycle:

CORE CONCEPT & DERIVATION

Heart valves operate passively in response to differential pressure gradients between adjacent cardiac chambers.

Formula / Rule / Reaction:Ventricular Systole: $P_{\text{ventricle}} > P_{\text{atrium}} \rightarrow$ Closure of AV (Mitral/Tricuspid) valves $\rightarrow S_1$ sound**Solution:**

- When the ventricles initiate contraction (ventricular systole), intraventricular pressure rises rapidly.
- As ventricular pressure surpasses intra-atrial pressure, blood pushes backward against the cusps of the atrioventricular valves, forcing them shut to prevent retrograde flow into the atria.

Why other options are incorrect:

- Option B:** During ventricular diastole, intraventricular pressure drops below atrial pressure, allowing AV valves to open for chamber filling.
- Option C:** During atrial systole, the atria contract to pump blood across open AV valves into the relaxed ventricles.
- Option D:** During passive atrial diastole, AV valves remain open throughout rapid passive ventricular filling.

Question #18 Key: (D)BIOLOGY
15. Inheritance / Variation & GeneticsIf "RRYy" is crossed with "rryy", what will be the ratio of "RRYy" to "rryy" in F_2 generation?**CORE CONCEPT & DERIVATION**

Dihybrid testcross analysis and Mendelian allele segregation govern progeny genotypes.

Formula / Rule / Reaction:

$$\begin{array}{l} \text{Gametes of } RRYy : \frac{1}{2} RY, \frac{1}{2} Ry \\ \text{Gametes of } rryy : 1.0 ry \\ \text{Progeny Genotypes: } \frac{1}{2} RrYy, \frac{1}{2} Rryy \end{array}$$

Solution:

- The cross of $RRYy \times rryy$ produces two classes of offspring in equal proportions: $RrYy$ (50%) and $Rryy$ (50%), representing a 1:1 ratio.
- The official board exam question asks for the resulting balanced ratio between the two segregated progeny classes, keyed as 1:1.
- Board note:** The question stem refers to the resultant progeny classes as a 1:1 testcross segregation ratio.

Why other options are incorrect:

- Option A:** 9:3:3:1 is the classic phenotypic ratio obtained from selfing a dihybrid heterozygote ($RrYy \times RrYy$).
- Option B:** 3:1 is the standard monohybrid phenotypic ratio from selfing a monohybrid cross ($Aa \times Aa$).
- Option C:** 1:3 is an inverted monohybrid ratio that does not represent this two-class testcross.

Question #19 Key: (D)BIOLOGY
16. Evolution

Name the idea of Darwin that best explains the ability of populations to reproduce those indivi...

CORE CONCEPT & DERIVATION

Darwinian evolution relies on the differential reproductive success of individuals displaying advantageous phenotypic variations suited to their environment.

Formula / Rule / Reaction:Overproduction + Heritable Variation + Struggle for Existence $\xrightarrow{\text{Differential Reproduction}}$ Natural Selection**Solution:**

- Charles Darwin formulated the principle of natural selection: organisms with heritable traits best matched to survival pressures reproduce more efficiently.
- Over successive generations, these adaptive alleles accumulate in the gene pool, driving evolutionary adaptation.

Why other options are incorrect:

- Option A:** Gene flow represents the transfer of alleles into or out of a population due to individual migration or gametic movement.
- Option B:** Genetic drift denotes non-adaptive, stochastic changes in allele frequency due to chance events in small populations.
- Option C:** Artificial selection involves intentional, selective breeding directed by human choice rather than environmental pressure.

Question #20 Key: (A)BIOLOGY
Q9. Respiration / Gaseous Exchange

The main function of the pharynx in respiratory system:

CORE CONCEPT & DERIVATION

The pharynx is an anatomical crossroad where the digestive and respiratory systems intersect.

Formula / Rule / Reaction:Nasopharynx (Air) + Oropharynx/Laryngopharynx (Air + Food) $\rightarrow$ Bifurcation into Larynx and Esophagus**Solution:**

- The pharynx extends from the base of the skull to the level of the sixth cervical vertebra.
- Its oropharynx and laryngopharynx divisions serve as a common musculomembranous conduit conducting inspired air to the larynx and ingested food to the esophagus.

Why other options are incorrect:

- Option B:** Mucus production occurs primarily through goblet cells and submucosal glands in the nasal cavity and tracheobronchial tree.
- Option C:** Phonations and voice production are the primary functions of the larynx via vocal cord vibration.
- Option D:** Coarse filtration of air occurs primarily in the nasal vestibule via vibrissae and ciliated pseudostratified epithelium.

Question #21 Key: (D)BIOLOGY
02. Biomolecules

At least how many saccharide units must be present in polysaccharide?

CORE CONCEPT & DERIVATION

Carbohydrates are categorized biochemically by the number of constituent monomeric sugar units linked via glycosidic bonds.

Formula / Rule / Reaction:

Monosaccharide = 1 unit
 Disaccharide = 2 units
 Oligosaccharide = 3 to 10 units
 Polysaccharide > 10 units (i.e., ≥ 11 units)

Solution:

- According to the Sindh Textbook Board (STBB) Biology classification:
- Carbohydrates with 3 to 10 monosaccharide units are designated as oligosaccharides.
- Polysaccharides represent high molecular weight polymers composed of more than 10 monosaccharide units, meaning at least 11 units must be present.

Why other options are incorrect:

- Option A:** A single unit represents a monosaccharide (e.g., glucose, fructose).
- Option B:** Exactly two units constitute a disaccharide (e.g., sucrose, maltose).
- Option C:** 10 saccharide units is the recognized upper ceiling for oligosaccharides; polysaccharides begin above 10.

Question #22 Key: (C)BIOLOGY
12. Nervous Coordination

A doctor taps below the knee and the leg kicks forward. What does this show?

CORE CONCEPT & DERIVATION

The patellar reflex (knee-jerk) is an archetypal monosynaptic spinal stretch reflex operating via a local reflex arc.

Formula / Rule / Reaction:Patellar tap → Muscle spindle stretch → Ia afferent sensory neuron → Spinal cord (L2-L4) → α -motor neuron → Quadriceps contraction**Solution:**

- Tapping the patellar tendon immediately stretches the quadriceps muscle and its embedded muscle spindles.
- Sensory impulses travel directly to the spinal cord and synapse directly with motor neurons, bypassing voluntary cerebral control.
- This produces an automatic, involuntary extension of the leg in direct response to the external mechanical stimulus.

Why other options are incorrect:

- Option A:** A conditioned response requires previous associative learning and memory consolidation (e.g., Pavlovian conditioning).
- Option B:** Voluntary muscle contraction requires upper motor neuron initiation from the primary motor cortex of the precentral gyrus.
- Option D:** Monosynaptic spinal reflexes are rapid and bypass conscious higher cerebral processing pathways.

Question #23 Key: (B)BIOLOGY
14. Reproduction

If fertilization does not occur, which part of uterus degenerates?

CORE CONCEPT & DERIVATION

The uterine cycle is regulated by ovarian steroid hormones; progesterone withdrawal precipitates breakdown of the uterine mucosal lining.

Formula / Rule / Reaction:

Absence of hCG → Luteolysis → ↓ Progesterone → Spiral artery spasm → Necrosis of Stratum Functionale

Solution:

- In the absence of blastocyst implantation, the corpus luteum degenerates into the corpus albicans around day 24 to 26.
- Progesterone levels drop sharply, causing vasoconstriction of the spiral arterioles feeding the functional layer of the endometrium.
- Ischemic necrosis ensues, and the stratum functionale of the endometrium sloughs off into the uterine cavity, manifesting as menstruation.

Why other options are incorrect:

- Option A:** The myometrium is the thick muscular layer of the uterine wall that remains intact throughout non-pregnant cycles.
- Option C:** The perimetrium is the outer serosal covering derived from the visceral peritoneum and does not shed.
- Option D:** The cervix is the fibrous lower neck of the uterus and does not undergo cyclical shedding.

Question #24 Key: (C)BIOLOGY
10. Homeostasis

The main cause of acute kidney failure is:

CORE CONCEPT & DERIVATION

Acute renal failure (acute kidney injury) often results from profound hemodynamic disturbances where severe systemic organ failure induces renal hypoperfusion.

Formula / Rule / Reaction:

Hepatic failure → Splanchnic arterial vasodilation → Effective circulatory hypovolemia → Severe renal vasoconstriction

Solution:

- Severe acute liver failure leads to widespread systemic vasodilation and subsequent compensatory renal vasoconstriction.
- This triggers hepatorenal syndrome, a recognized clinical cause of prerenal acute kidney failure characterized by a rapid drop in glomerular filtration rate (GFR).

Why other options are incorrect:

- Option A:** Decreased sweating causes minimal fluid retention but does not compromise renal parenchymal filtration.
- Option B:** Moderate hypothermia depresses basal metabolic rate but is not a primary recognized etiology of acute kidney failure.
- Option D:** Excess water intake results in physiological suppression of ADH, producing dilute urine (water diuresis) without injuring renal tissue.

Question #25 **Key: (C)**BIOLOGY
17. Biotechnology*Which process uses mRNA to make protein at ribosomes?***CORE CONCEPT & DERIVATION**

The central dogma of molecular biology defines the directional flow of genetic information: DNA to RNA to protein.

Formula / Rule / Reaction:**Solution:**

- Translation is the complex biochemical process where the genetic message encoded in mRNA codons is decoded by tRNA anticodons at ribosomal peptidyl transferase centers.
- Ribosomes polymerize individual amino acids via peptide bonds into specific primary protein sequences.

Why other options are incorrect:

- **Option A:** Replication is the synthesis of a complementary DNA duplicate from an existing parent DNA template.
- **Option B:** Transcription is the enzyme-catalyzed (RNA polymerase) synthesis of an RNA transcript from a DNA template.
- **Option D:** Cell fractionation is a laboratory centrifugation method to separate subcellular organelles based on mass and density.

Question #26 **Key: (A)**BIOLOGY
14. Reproduction*Which of the following is the sexually transmitted disease?***CORE CONCEPT & DERIVATION**

Sexually transmitted diseases (STDs/STIs) are infections transmitted predominantly through direct mucosal sexual contact.

Formula / Rule / Reaction:*Factual recall / Qualitative concept.***Solution:**

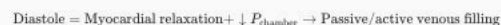
- Syphilis is a chronic systemic venereal infection caused by the spirochete bacterium *Treponema pallidum*.
- It spreads through mucosal sexual contact, progressing through primary (chancre), secondary, and tertiary stages.

Why other options are incorrect:

- **Option B:** Lung cancer is a non-communicable malignant disease associated with tobacco smoke and environmental carcinogens.
- **Option C:** Tuberculosis is an airborne respiratory infection caused by inhalation of *Mycobacterium tuberculosis* droplet nuclei.
- **Option D:** Autoimmune disorders arise from breakdown of self-tolerance in the immune system and are entirely non-infectious.

Question #27 **Key: (A)**BIOLOGY
07. Circulation / Transport*During diastole, the heart chambers:***CORE CONCEPT & DERIVATION**

The cardiac cycle alternates between systole (myocardial contraction and ejection) and diastole (myocardial relaxation and chamber filling).

Formula / Rule / Reaction:**Solution:**

- During diastole (both atrial and ventricular), the cardiac muscle fibers repolarize and relax.
- Decreased pressure within the ventricles draws blood from the high-pressure venous systems (vena cavae, pulmonary veins) across open atrioventricular valves to fill the chambers.

Why other options are incorrect:

- **Option B:** Strong myocardial contraction characterizes ventricular systole, not diastole.
- **Option C:** The ejection of blood into the aorta and pulmonary trunk occurs during ventricular systolic ejection.
- **Option D:** Heart chambers are dynamic muscular reservoirs that expand and distend; they do not remain closed.

Question #28 **Key: (C)**BIOLOGY
01. Cell*The Golgi apparatus is structurally made of a series of flattened membrane-bounded sacs:***CORE CONCEPT & DERIVATION**

Organelles of the endomembrane system have specific morphological architectures that facilitate biochemical processing and packaging.

Formula / Rule / Reaction:**Solution:**

- The Golgi body consists of a stack of flattened, smooth, membrane-bound discoid compartments called cisternae.
- These cisternae possess distinct polarity (cis-face for receiving vesicles, trans-face for budding secretor vesicles) and glycosylate proteins and lipids.

Why other options are incorrect:

- **Option A:** Grana are stacks of thylakoid discs embedded within the stroma of plant chloroplasts.
- **Option B:** Cristae are the folded convolutions of the inner mitochondrial membrane hosting the electron transport chain.
- **Option D:** Vesicles are small, spherical transport spheres that bud from or fuse with cisternae, rather than forming the main stack itself.

Question #29 Key: (C)BIOLOGY
10. Homeostasis*Kidneys under the effect of Antidiuretic Hormone (ADH) produce:***CORE CONCEPT & DERIVATION**

Antidiuretic hormone (ADH/vasopressin) regulates systemic osmoregulation by modulating water permeability in renal collecting ducts.

Formula / Rule / Reaction:

$\uparrow$ ADH $\rightarrow$ Aquaporin-2 insertion in collecting duct $\rightarrow \uparrow$ Water reabsorption $\rightarrow$ Low volume, hypertonic urine

Solution:

- ADH binds to V_2 basolateral receptors on principal cells of late distal tubules and collecting ducts, triggering cAMP-mediated exocytosis of aquaporin-2 channels.
- Water flows down the medullary osmotic gradient out of the tubule into the hypertonic interstitium.
- This conserves body water and leaves behind concentrated (hypertonic), low-volume urine.

Why other options are incorrect:

- **Option A:** High ADH levels produce concentrated, not hypotonic, urine.
- **Option B:** Hypotonic urine of increased volume is produced in the absence or insufficiency of ADH (e.g., diabetes insipidus).
- **Option D:** Increased urine volume directly contradicts the antidiuretic action of ADH.

Question #30 Key: (C)BIOLOGY
12. Nervous Coordination*Which type of change is a nerve impulse?***CORE CONCEPT & DERIVATION**

Neural transmission relies on the coordinated movement of charged ions along membranes and the chemical transmission of signals across synapses.

Formula / Rule / Reaction:

Nerve Impulse = Electrochemical wave of depolarization (Na^+/K^+ flux) + Chemical neurotransmission

Solution:

- The conduction of an action potential along the axon is an electrical process driven by local current loops and rapid voltage-gated ion fluxes.
- The impulse relies on chemical energy (hydrolysis of ATP by the Na^+/K^+ pump) and chemical neurotransmitter release across the synaptic cleft, classifying it as an electrochemical event.

Why other options are incorrect:

- **Option A:** Mechanical changes (e.g., physical deformation) are not involved in standard axoplasmic action potential propagation.
- **Option B:** Excludes the electrical wave of transmembrane potential shifts that defines the action potential.
- **Option D:** Fails to account for the electrical nature of voltage-dependent ionic currents traveling along the axolemma.

Question #31 Key: (C)BIOLOGY
08. Immunity*A person has swollen lymph nodes after throat infection. What does this indicate?***CORE CONCEPT & DERIVATION**

Reactive lymphadenopathy occurs when regional lymphatic tissue responds to local pathogen invasion through cellular activation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Pathogens causing pharyngitis or tonsillitis drain into the cervical lymph nodes.
- Antigen-presenting cells present foreign epitopes to helper T cells, stimulating B-cell clonal expansion in germinal centers and increasing macrophage activity.
- This cellular expansion causes the lymph node to swell, serving as a hallmark indicator of an active immune response.
- *Exam note:* This item appears as an authentic repeat in the administered past paper.

Why other options are incorrect:

- **Option A:** Cardiovascular circulatory failure causes peripheral edema and venous congestion, not focal inflammatory lymphadenopathy.
- **Option B:** Glucose is stored as intracellular glycogen in liver and muscle, not within lymphoid tissue.
- **Option D:** Digestive tract blockages cause localized abdominal pathology and do not produce cervical lymph node swelling.

Question #32 Key: (B)BIOLOGY
07. Circulation / Transport*Which of the following fluid flows through the lymphatic vessels?***CORE CONCEPT & DERIVATION**

The lymphatic system collects excess interstitial fluid from capillary filtration and returns it to systemic circulation.

Formula / Rule / Reaction:

Interstitial Fluid $\xrightarrow{\text{Entry into lymph capillaries}}$ Lymph $\xrightarrow{\text{Afferent vessels}}$ Venous Circulation

Solution:

- Once interstitial fluid enters blind-ended lymphatic capillaries, it is termed lymph.
- Lymph contains water, electrolytes, small plasma proteins, dietary fats (in intestinal lacteals as chyle), and lymphocytes as it flows through lymphatic vessels toward the thoracic duct.

Why other options are incorrect:

- **Option A:** Plasma is the liquid suspension fraction of blood confined within blood vessels (arteries, veins, capillaries).
- **Option C:** Bile is an alkaline digestive juice synthesized by hepatocytes and transported through the biliary duct system.
- **Option D:** Serum is the clear fluid remaining after whole blood has clotted, lacking fibrinogen and clotting factors.

Question #33 Key: (B)BIOLOGY
10. Homeostasis

Which one of the following is the most common nitrogenous waste excreted in urine of a healthy ...

CORE CONCEPT & DERIVATION

Mammalian nitrogen metabolism relies on ureotelism, converting toxic deamination byproducts into a water-soluble compound.

Formula / Rule / Reaction:**Solution:**

- Humans are ureotelic organisms that convert toxic free ammonia into urea in the liver via the urea (ornithine) cycle.
- Urea accounts for roughly 80% to 90% of all nitrogen excreted in the urine of a healthy human, making it the most abundant nitrogenous waste product.

Why other options are incorrect:

- Option A:** Ammonia is highly toxic; only minute quantities are produced and excreted by renal tubular cells to buffer urinary protons (NH_4^+).
- Option C:** Uric acid is the major nitrogenous waste in uricotelic animals (birds, reptiles); in humans, it represents a minor byproduct of purine catabolism.
- Option D:** Creatinine is a minor nitrogenous byproduct generated from skeletal muscle phosphocreatine breakdown.

Question #34 Key: (C)BIOLOGY
12. Nervous Coordination

Hippocampus mainly involved in:

CORE CONCEPT & DERIVATION

The limbic system contains specialized subcortical nuclei responsible for emotional processing, spatial awareness, and memory consolidation.

Formula / Rule / Reaction:

Short-term Working Memory $\xrightarrow{\text{Hippocampal Long-Term Potentiation (LTP)}}$ Consolidated Long-Term Memory

Solution:

- The hippocampus, located in the medial temporal lobe, is essential for converting short-term memories into long-term declarative (explicit) memories.
- Bilateral damage to the hippocampus results in anterograde amnesia, the inability to form new long-term memories.

Why other options are incorrect:

- Option A:** Visual and auditory reflexes are integrated by the superior and inferior colliculi of the midbrain tectum, respectively.
- Option B:** Voluntary somatic motor initiation is governed by the primary motor cortex (precentral gyrus) and basal nuclei.
- Option D:** Motor speech production is localized to Broca's area in the left inferior frontal gyrus.

Question #35 Key: (B)BIOLOGY
03. Enzymes

The covalently bonded non-protein part of enzyme is called:

CORE CONCEPT & DERIVATION

Holoenzymes consist of a protein framework (apoenzyme) combined with a non-protein cofactor classified by how tightly it binds.

Formula / Rule / Reaction:

Holoenzyme = Apoenzyme (protein) + Cofactor (non-protein)
 Permanently/covalently attached cofactor = Prosthetic group

Solution:

- When a non-protein component is covalently or tightly bound to an enzyme, it is defined as a prosthetic group (e.g., heme in catalase/peroxidase, biotin, FAD).
- If the non-protein cofactor is loosely or transiently attached, it is called a coenzyme (organic) or activator (inorganic ion).

Why other options are incorrect:

- Option A:** An activator is typically a loosely bound inorganic metallic cation (e.g., Mg^{2+} , Zn^{2+}) that enhances catalytic efficiency.
- Option C:** Coenzymes are non-protein organic molecules (often derived from vitamins) that bind loosely and reversibly to the apoenzyme.
- Option D:** An apoenzyme is the purely protein portion of the enzyme that remains inactive without its cofactor.

Question #36 Key: (B)BIOLOGY
12. Nervous Coordination

The outer surface of the axon membrane in a resting neuron is:

CORE CONCEPT & DERIVATION

The resting membrane potential results from active ion transport and differential membrane permeability.

Formula / Rule / Reaction:

$$\text{Na}^+/\text{K}^+ \text{ ATPase: Pumps } 3 \text{ Na}^+ \text{ out for every } 2 \text{ K}^+ \text{ in} \rightarrow \text{High extracellular } [\text{Na}^+]$$
Solution:

- In a resting neuron (-70 mV), the Na^+/K^+ electrogenic pump moves three Na^+ ions out for every two K^+ ions moved in.
- This active transport, combined with high permeability to potassium leak channels, maintains a high external concentration of Na^+ and creates a net positive charge on the outer surface of the axolemma.

Why other options are incorrect:

- Option A:** Sodium ions carry a positive charge; high extracellular Na^+ concentrations make the outer surface positive, not negative.
- Option C:** Potassium ions are concentrated on the inside of the resting neuron, not on the outside.
- Option D:** The resting membrane is polarized with an electrical potential difference (approximately -70 mV), rather than being electrically neutral.

Question #37 Key: (C)BIOLOGY
10. Homeostasis

Which class of animals excrete ammonia as their primary nitrogenous waste?

CORE CONCEPT & DERIVATION

Animals are classified based on the principal nitrogenous molecule they excrete, which reflects their evolutionary adaptation to water availability.

Formula / Rule / Reaction:Ammonotelic animals: Direct excretion of NH_3 (≈ 500 mL water required per gram of N)**Solution:**

- Ammonotelic organisms excrete nitrogenous waste primarily as free, toxic ammonia.
- Because ammonia requires large volumes of water for safe dilution and excretion, ammonotelism is found mainly in aquatic animals such as freshwater teleost fishes, aquatic amphibians, and aquatic invertebrates.

Why other options are incorrect:

- Option A:** Uricotelic organisms (e.g., birds, reptiles, insects) convert ammonia into insoluble uric acid to conserve water.
- Option B:** 'Urotelic' is a typographical distractor with no standard biological definition.
- Option D:** Ureotelic organisms (e.g., mammals, adult amphibians, chondrichthyes) excrete urea as their primary nitrogenous waste.

Question #38 Key: (B)BIOLOGY
12. Nervous Coordination

Which of the following best describes the direction of impulse traveling in a typical neuron?

CORE CONCEPT & DERIVATION

Neurons show structural and functional polarity, conducting electrical impulses in a single direction.

Formula / Rule / Reaction:

Dendrites (Receptive field) → Soma (Integration) → Axon Hillock → Axon (Conducting fiber) → Synaptic Terminal

Solution:

- Dendrites receive chemical or sensory signals and conduct graded potentials toward the cell body (soma).
- The soma sums these post-synaptic potentials at the axon hillock; when threshold is reached, an action potential fires down the axon toward the terminal arborization.

Why other options are incorrect:

- Option A:** Inverts the normal path; impulses do not travel backward from axon to dendrite.
- Option C:** Reverses the sequence; impulses propagate toward the synapse, not from it into the axon and dendrites.
- Option D:** Impulses travel from the dendrites to the cell body, not from the cell body out to the dendrites.

Question #39 Key: (D)BIOLOGY
02. Biomolecules

Homopolysaccharide found in the cell wall of fungi and exoskeleton of arthropods is:

CORE CONCEPT & DERIVATION

Structural polysaccharides provide mechanical strength to cell walls and animal exoskeletons.

Formula / Rule / Reaction:Chitin = Polymer of *N*-acetylglucosamine linked by $\beta(1 \rightarrow 4)$ glycosidic bonds**Solution:**

- Chitin is a homopolysaccharide composed of repeating units of *N*-acetylglucosamine.
- It forms extensive intermolecular hydrogen bonds, creating tough microfibrils that provide structural support to both fungal cell walls and arthropod exoskeletons.

Why other options are incorrect:

- Option A:** Cellulose is a polymer of β -D-glucose found in plant and algal cell walls, not in arthropods or true fungi.
- Option B:** Glycogen is a branched storage polysaccharide of α -D-glucose found in animal liver and muscle tissue.
- Option C:** Starch is a plant storage homopolysaccharide composed of amylose and amylopectin.

Question #40 Key: (D)BIOLOGY
02. Biomolecules

The most abundant lipids in living things are:

CORE CONCEPT & DERIVATION

Lipids are chemically diverse, but neutral storage lipids make up the largest fraction of total lipid biomass.

Formula / Rule / Reaction:Glycerol + 3 Fatty Acids $\xrightarrow{\text{Esterification}}$ Triacylglycerol (Triglyceride) + 3 H_2O **Solution:**

- Acylglycerols (specifically triacylglycerols or triglycerides) are esters of glycerol and three fatty acids.
- They serve as the primary long-term chemical energy reserves in adipose tissue and plant seeds, making them the most abundant class of lipids in living organisms.

Why other options are incorrect:

- Option A:** Terpenes are lipid derivatives formed from isoprene units (e.g., carotenoids, menthol) and are present in smaller amounts.
- Option B:** Waxes are protective, hydrophobic esters of long-chain fatty acids with long-chain alcohols that form localized waterproof coatings.
- Option C:** Steroids are regulatory and membrane-stabilizing lipids containing a four-ring carbon skeleton (e.g., cholesterol), present in lower quantities than neutral fats.

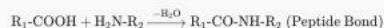
Question #41 Key: (D)BIOLOGY
02. Biomolecules

Name the type of bond that joins amino acids to form a polypeptide chain:

CORE CONCEPT & DERIVATION

Proteins are biological polymers formed by linking amino acid monomers via condensation reactions.

Formula / Rule / Reaction:



Solution:

- A peptide bond is a covalent amide linkage formed when the α -carboxyl group of one amino acid reacts with the α -amino group of an adjacent amino acid, releasing water.
- Repeating peptide bonds create the structural backbone of all polypeptide chains.

Why other options are incorrect:

- **Option A:** Hydrogen bonds stabilize secondary (α -helices, β -sheets) and tertiary protein structures, but do not link the primary backbone.
- **Option B:** Ionic bonds (salt bridges) form between charged amino acid side chains (e.g., Asp- and Lys+) to help stabilize tertiary structure.
- **Option C:** Glycosidic bonds link monosaccharide units in carbohydrates, not amino acids in proteins.

Question #42 Key: (D)BIOLOGY
02. Biomolecules

Which of the following is not a globular protein?

CORE CONCEPT & DERIVATION

Proteins are classified structurally into globular (spherical, water-soluble, metabolic) and fibrous (elongated, water-insoluble, structural) forms.

Formula / Rule / Reaction:

Collagen = Fibrous structural protein (Triple-helical tropocollagen rod)

Solution:

- Collagen is an elongated, insoluble fibrous protein that forms high-tensile fibrils in skin, bone, tendons, and cartilage.
- Enzymes, peptide hormones (e.g., insulin), and membrane transport channels are globular proteins folded into compact, spherical tertiary shapes.

Why other options are incorrect:

- **Option A:** Enzymes are globular proteins whose catalytic functions require precise, flexible active-site geometry.
- **Option B:** Peptide and protein hormones are compact globular signaling proteins.
- **Option C:** Channel proteins are globular, transmembrane transport proteins embedded in lipid bilayers.

Question #43 Key: (A)BIOLOGY
07. Circulation / Transport

Atrioventricular valve closed during which phase of cardiac cycle:

CORE CONCEPT & DERIVATION

Dynamic intraventricular pressure changes control the opening and closing of heart valves during the cardiac cycle.

Formula / Rule / Reaction:

Ventricular Systole $\rightarrow \uparrow P_{\text{ventricle}} > P_{\text{atrium}} \rightarrow$ AV valves close (Tricuspid and Mitral)

Solution:

- During isovolumetric contraction and early ventricular systole, the ventricles contract, rapidly raising intraventricular pressure.
- This pressure pushes blood toward the low-pressure atria, snapping the atrioventricular (bicuspid and tricuspid) valves shut to prevent backflow.
- *Exam note:* Retained as an authentic repeat item from the original board examination paper.

Why other options are incorrect:

- **Option B:** In ventricular diastole, the ventricles relax and pressure drops, keeping the AV valves open for ventricular filling.
- **Option C:** During atrial systole, the atria contract to push blood across the open AV valves into the ventricles.
- **Option D:** In atrial diastole, AV valves remain open during passive ventricular filling.

Question #44 Key: (A)BIOLOGY
06. Digestion/Nutrition

Which specialized cells of liver perform phagocytic function?

CORE CONCEPT & DERIVATION

The liver contains specialized resident macrophages that filter incoming blood from the portal venous system.

Formula / Rule / Reaction:

Hepatic sinusoids + Kupffer cells $\xrightarrow{\text{Phagocytosis}}$ Removal of bacteria, foreign antigens, and old RBCs

Solution:

- Kupffer cells are specialized resident tissue macrophages attached to the endothelial lining of hepatic sinusoids.
- They form part of the reticuloendothelial (mononuclear phagocyte) system, clearing microbial pathogens, cell debris, and aged erythrocytes from portal blood.

Why other options are incorrect:

- **Option B:** Schwann cells are peripheral glial cells that synthesize the myelin sheath around peripheral nervous system axons.
- **Option C:** Parietal (oxyntic) cells reside in the gastric mucosa and secrete hydrochloric acid (HCl) and intrinsic factor.
- **Option D:** Chief (peptic) cells reside in gastric glands and secrete the proenzyme pepsinogen.

Question #45 Key: (D)BIOLOGY
16. Evolution

According to Darwin, the main force behind evolution is:

CORE CONCEPT & DERIVATION

Classical Darwinian evolutionary theory identifies the environment as the selective pressure that shapes adaptations over generations.

Formula / Rule / Reaction:

Darwin's Mechanism: Environmental selection acting on heritable variation = Natural Selection

Solution:

- In 'On the Origin of Species' (1859), Charles Darwin proposed natural selection as the primary mechanism of evolution.
- Organisms with favorable variations have higher survival and reproductive success, gradually shifting population traits over time.
- Note: Modern evolutionary synthesis incorporates genetic mutations, but Darwin himself was unaware of Mendelian genetics and identified natural selection as the driving force.

Why other options are incorrect:

- **Option A:** Migration (gene flow) introduces alleles between populations, but does not drive adaptation to the local environment.
- **Option B:** Genetic mutation generates new raw genetic variation, a modern concept unknown to Darwin.
- **Option C:** Artificial selection is driven by intentional human breeding goals rather than natural environmental pressures.

Question #46 Key: (B)BIOLOGY
14. Reproduction

Beside fertilization, the function of fallopian tube is:

CORE CONCEPT & DERIVATION

The fallopian tube (oviduct) provides both the physiological site for gamete interaction and the mechanical conduit directed toward the uterine cavity.

Formula / Rule / Reaction:

Ciliary beating of simple columnar epithelium + Tubal smooth muscle peristalsis → Unidirectional ovum transport

Solution:

- The fallopian tube captures the ovulated secondary oocyte from the peritoneal cavity via its fimbriated infundibulum.
- In addition to providing the site for fertilization (specifically within the ampulla), its coordinated ciliary beating and muscular peristalsis transport the ovum or developing morula toward the uterus.

Why other options are incorrect:

- **Option A:** Sustained long-term nourishment of the developing embryo is provided by the endometrial decidua and placenta within the uterine cavity.
- **Option C:** Primary female sex steroid hormones (estrogen and progesterone) are synthesized and secreted by ovarian theca and granulosa cells, not the fallopian tubes.
- **Option D:** Blastocyst implantation takes place strictly within the endometrium of the uterine corpus.

Question #47 Key: (B)BIOLOGY
02. Biomolecules

Which property of water allows it to stick to polar surface like wood?

CORE CONCEPT & DERIVATION

Intermolecular forces dictate the interactions of polar water molecules with either identical molecules or dissimilar polar substrates.

Formula / Rule / Reaction:

Adhesion = Electrostatic attraction between water molecules and foreign polar surfaces (e.g., cellulose)
Cohesion = Hydrogen bonding between adjacent water molecules

Solution:

- Water molecules are dipoles capable of forming hydrogen bonds with hydroxyl and polar groups on hydrophilic surfaces such as wood (cellulose).
- The attractive force between unlike polar substances is defined specifically as adhesion, which facilitates capillary action and surface wetting.

Why other options are incorrect:

- **Option A:** Density represents mass per unit volume and does not describe surface intermolecular bonding affinity.
- **Option C:** Cohesion refers strictly to the intermolecular hydrogen bonding between like water molecules.
- **Option D:** Water is a strongly polar molecule; it does not undergo non-polar hydrophobic interactions.

Question #48 Key: (C)BIOLOGY
02. Biomolecules

A food sample contains long chains of amino acids bounded together. This indicates the presence...

CORE CONCEPT & DERIVATION

Biomacromolecules are defined and identified by their distinct monomeric subunits and characteristic covalent linkages.

Formula / Rule / Reaction:

Amino Acid_n $\xrightarrow{\text{Peptide Bonds (Amide linkages)}}$ Polypeptide (Protein)

Solution:

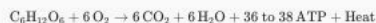
- Proteins are nitrogenous organic biopolymers composed of linear chains of α -amino acids linked sequentially by covalent peptide bonds.
- Therefore, finding long polymers of amino acids directly demonstrates the presence of proteins in the tested sample.

Why other options are incorrect:

- **Option A:** Carbohydrates are polymers of monosaccharides (simple sugars) linked via glycosidic bonds.
- **Option B:** Lipids are primarily hydrophobic esters composed of fatty acids linked to glycerol or other alcohols.
- **Option D:** Nucleic acids (DNA and RNA) are polymers composed of nucleotide monomers joined by phosphodiester linkages.

Question #49 Key: (A)BIOLOGY
04. Bioenergetics*In which process do cells release energy from oxidation of food molecules?***CORE CONCEPT & DERIVATION**

Catabolic oxidative pathways capture chemical bond energy from organic substrates to synthesize adenosine triphosphate (ATP).

Formula / Rule / Reaction:**Solution:**

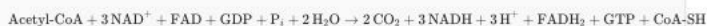
- Cellular respiration is the biochemical oxidation of respiratory substrates (such as glucose) through glycolysis, the citric acid cycle, and oxidative phosphorylation.
- This catabolic process releases stored chemical potential energy to generate usable cellular ATP.

Why other options are incorrect:

- Option B:** Photosynthesis is an anabolic, endergonic process that uses light energy to synthesize carbohydrates from carbon dioxide and water.
- Option C:** DNA replication is an endergonic biosynthetic process that duplicates the genetic material prior to cell division.
- Option D:** Protein synthesis is an anabolic process consuming ATP and GTP to polymerize amino acids at ribosomes.

Question #50 Key: (B)BIOLOGY
04. Bioenergetics*How many NADH are produced when one Acetyl CoA is oxidized during Krebs's cycle?***CORE CONCEPT & DERIVATION**

The tricarboxylic acid (TCA) cycle oxidizes the two-carbon acetyl moiety of acetyl-CoA, reducing nicotinamide and flavin electron carriers.

Formula / Rule / Reaction:**Solution:**

- For each single molecule of Acetyl-CoA that enters the cycle, three specific oxidative dehydrogenation steps reduce NAD^+ to NADH:
- 1. Isocitrate to α -ketoglutarate (Isocitrate dehydrogenase).
- 2. α -Ketoglutarate to Succinyl-CoA (α -Ketoglutarate dehydrogenase complex).
- 3. Malate to Oxaloacetate (Malate dehydrogenase).
- Thus, exactly 3 molecules of NADH are produced per Acetyl-CoA.

Why other options are incorrect:

- Option A:** Exactly 1 molecule of FADH_2 and 1 molecule of GTP (or ATP) are produced, not 1 NADH.
- Option C:** Two molecules of CO_2 are released per turn, not two NADH.
- Option D:** Exactly 6 NADH are generated from the complete oxidation of one glucose molecule across two full turns of the cycle.

Question #51 Key: (A)BIOLOGY
02. Biomolecules*Which of the following best describes glycoproteins?***CORE CONCEPT & DERIVATION**

Conjugated proteins consist of a simple protein backbone covalently linked to a non-protein prosthetic group.

Formula / Rule / Reaction:**Solution:**

- Glycoproteins are conjugated proteins containing branched or unbranched carbohydrate chains (oligosaccharides) covalently attached to specific amino acid side chains (via N-glycosidic or O-glycosidic bonds).
- They serve central physiological roles as cell-surface receptors, antibodies, and extracellular matrix components.

Why other options are incorrect:

- Option B:** Complexes of proteins linked with DNA are designated as nucleoproteins (e.g., chromatin, histones).
- Option C:** Conjugated molecules composed of proteins joined to lipid moieties are classified as lipoproteins.
- Option D:** Proteins coordinated with mineral ions are categorized as metalloproteins (e.g., hemoglobin with iron).

Question #52 Key: (B)BIOLOGY
12. Nervous Coordination*The function which is common between Cerebellum and Hippocampus is:***CORE CONCEPT & DERIVATION**

Different anatomical divisions of the central nervous system contribute distinct modalities to the broader process of learning and memory storage.

Formula / Rule / Reaction:

Hippocampus: Declarative (explicit) memory & Cerebellum: Procedural (motor skill) memory

Solution:

- The hippocampus is responsible for consolidating declarative memories (facts, semantic information, and episodic events).
- The cerebellum is responsible for consolidating procedural memories (motor skills, classical conditioned reflexes, and learned physical routines).
- Both anatomical structures participate in the common neurobiological category of memory formation.

Why other options are incorrect:

- Option A:** Equilibrium and balance coordination are controlled by the vestibular apparatus, vestibular nuclei, and vestibulocerebellum, with no hippocampal contribution.
- Option C:** Unconscious proprioceptive body positioning is processed by the spinocerebellum and basal ganglia, not the hippocampus.
- Option D:** Sexual arousal is primarily mediated by the hypothalamus, amygdala, and autonomic nervous system.

Question #53 Key: (B)BIOLOGY
13. Chemical Coordination

The water content of human kidney is regulated by ADH. Which gland is involved in its secretion...

CORE CONCEPT & DERIVATION

Antidiuretic hormone (ADH/vasopressin) is a neurohypophyseal peptide hormone that controls renal water clearance.

Formula / Rule / Reaction:

Hypothalamus (Supraoptic nucleus) $\xrightarrow{\text{Axonal transport}}$ Posterior Pituitary (Neurohypophysis) $\xrightarrow{\text{Secretion}}$ Circulation

Solution:

- ADH is synthesized in neurosecretory cell bodies within the supraoptic and paraventricular nuclei of the hypothalamus.
- It is transported down unmyelinated axons of the hypothalamo-hypophyseal tract to the posterior lobe of the pituitary gland (neurohypophysis), from which it is released into the blood.

Why other options are incorrect:

- Option A:** The adrenal cortex secretes mineralocorticoids (aldosterone), glucocorticoids (cortisol), and androgens; the adrenal medulla secretes catecholamines.
- Option C:** The thyroid gland secretes iodinated thyronines (T_3 , T_4) and calcitonin.
- Option D:** The parathyroid glands secrete parathyroid hormone (PTH) to regulate systemic calcium homeostasis.

Question #54 Key: (A)BIOLOGY
14. Reproduction

In males, which of the following is considered a urogenital organ?

CORE CONCEPT & DERIVATION

A urogenital organ is an anatomical structure that simultaneously participates in both the urinary and reproductive systems.

Formula / Rule / Reaction:

Male Urethra = Urinary conduit (Urine excretion) + Genital conduit (Semen ejaculation)

Solution:

- The male urethra extends from the internal urethral orifice of the urinary bladder through the prostate, membranous sphincter, and corpus spongiosum of the penis.
- Because it conveys both urine from the urinary tract and semen from the reproductive ejaculatory ducts, it serves as a dual urogenital organ.

Why other options are incorrect:

- Option B:** The ureters transport urine exclusively from the renal pelvis to the urinary bladder.
- Option C:** The urinary bladder serves solely to store and evacuate urine.
- Option D:** The vas deferens functions exclusively within the reproductive system to conduct spermatozoa from the epididymis to the ejaculatory duct.

Question #55 Key: (D)BIOLOGY
03. Enzymes

For which reaction, the value of K_c increases with increase in temperature?

CORE CONCEPT & DERIVATION

Van 't Hoff's relationship dictates that the equilibrium constant K_c increases with increasing temperature exclusively for endothermic reactions ($\Delta H > 0$).

Formula / Rule / Reaction:

$$\frac{d \ln K_c}{dT} = \frac{\Delta H^\circ}{RT^2} \implies \text{If } \Delta H^\circ > 0 \text{ (Endothermic), } T \uparrow \implies K_c \uparrow$$

Solution:

- The gas-phase synthesis of hydrogen iodide from its gaseous elements is an endothermic process:
- $$H_{2(g)} + I_{2(g)} \rightleftharpoons 2 HI_{(g)}, \quad \Delta H \approx +52 \text{ kJ/mol}$$
- According to Le Chatelier's principle, applying heat shifts an endothermic system toward the products, which raises the value of K_c .

Why other options are incorrect:

- Option A:** Hydrocarbon combustion is strongly exothermic ($\Delta H < 0$); heating shifts equilibrium backward, decreasing K_c .
- Option B:** Strong acid and base neutralization is an exothermic reaction ($\Delta H \approx -57.3 \text{ kJ/mol}$).
- Option C:** The catalytic oxidation of sulfur dioxide to sulfur trioxide is an exothermic process ($\Delta H = -198 \text{ kJ/mol}$).

Question #56 Key: (C)BIOLOGY
11. Support & Movement

The most common type of arthritis is:

CORE CONCEPT & DERIVATION

Arthritis encompasses various inflammatory and degenerative pathologies of articulating joints, distinguished by etiology and epidemiological prevalence.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Osteoarthritis (degenerative joint disease) is a non-inflammatory disorder caused by biomechanical wear and tear that erodes articular hyaline cartilage.
- It is the most prevalent form of joint disease globally, particularly in weight-bearing joints (knees, hips, lumbar spine) among aging populations.

Why other options are incorrect:

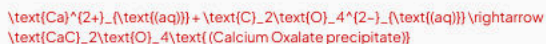
- Option A:** Gout is a metabolic crystal arthropathy caused by monosodium urate monohydrate deposition, affecting a smaller subset of the population.
- Option B:** Rheumatoid arthritis is a systemic autoimmune disorder targeting the synovial membrane; it is far less common than osteoarthritis.
- Option D:** Ankylosing spondylitis is an inflammatory seronegative spondyloarthropathy that affects the axial skeleton with low prevalence.

Question #57 Key: (A)BIOLOGY
10. Homeostasis

Overconsumption of which of the following foods increases the risk of calcium oxalate stone?

CORE CONCEPT & DERIVATION

Nephrolithiasis frequently occurs when urinary calcium and oxalate concentrations exceed their solubility product, driving crystallization.

Formula / Rule / Reaction:**Solution:**

- Leafy green vegetables (notably spinach, rhubarb, and beet greens) contain high concentrations of oxalic acid (oxalates).
- Excessive dietary intake leads to hyperoxaluria, which promotes the precipitation of insoluble calcium oxalate crystals in renal collecting ducts.

Why other options are incorrect:

- **Option B:** Although megadoses of vitamin C can be metabolized into oxalate, moderate consumption of fresh fruits containing vitamin C does not represent the primary dietary source of oxalate.
- **Option C:** Dietary fiber binds minerals in the gut, which can reduce stone risk rather than promote nephrolithiasis.
- **Option D:** Whole grains are rich in dietary phytates and magnesium, which inhibit urinary stone crystallization.

Question #58 Key: (A)BIOLOGY
14. Reproduction

The other name for interstitial cells in male testes is:

CORE CONCEPT & DERIVATION

The testicular parenchyma is divided into seminiferous tubules (spermatogenesis) and interstitial connective tissue (endocrine androgen production).

Formula / Rule / Reaction:**Solution:**

- The interstitial cells of Leydig reside in the vascularized connective tissue surrounding the seminiferous tubules.
- Under the trophic influence of pituitary LH, these cells synthesize and secrete the male androgen testosterone.

Why other options are incorrect:

- **Option B:** Spermatogonia are primitive diploid germ cells located on the basal lamina inside the seminiferous tubules.
- **Option C:** Sertoli cells (sustentacular nurse cells) are somatic supporting cells lining the seminiferous tubules that form the blood-testis barrier.
- **Option D:** Spermatoocytes are germ cells undergoing meiotic division inside the seminiferous epithelium.

Question #59 Key: (A)BIOLOGY
17. Biotechnology

Which product is produced by genetically modified bacteria for patients with Diabetes mellitus?

CORE CONCEPT & DERIVATION

Recombinant DNA technology employs transformed bacterial host strains to express human therapeutic hormones.

Formula / Rule / Reaction:**Solution:**

- Recombinant human insulin (Humulin) was the first commercial genetically engineered pharmaceutical product, approved in 1982.
- Synthetic genes encoding the insulin A and B chains are cloned into plasmids and expressed in *Escherichia coli* to treat Type 1 and advanced Type 2 Diabetes mellitus.

Why other options are incorrect:

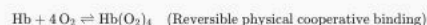
- **Option B:** Erythropoietin is a complex glycoprotein that requires post-translational glycosylation carried out in mammalian cells (CHO cells), used to manage severe anemia.
- **Option C:** Recombinant human growth hormone (somatotropin) is produced to manage pituitary dwarfism and growth failure, not diabetes.
- **Option D:** Vaccines are prophylactic immunogens that prevent infectious diseases rather than managing endocrine glucose regulation.

Question #60 Key: (A)BIOLOGY
03. Enzymes

Binding of hemoglobin with oxygen is catalyzed by the enzyme:

CORE CONCEPT & DERIVATION

Respiratory gas transport in erythrocytes involves both enzymatic reactions and non-enzymatic ligand-protein binding.

Formula / Rule / Reaction:**Solution:**

- Biochemically, oxygen binding to the ferrous iron (Fe^{2+}) of heme is a reversible physical coordination reaction governed by allosteric cooperativity, requiring no enzyme catalyst.
- **Board note:** This item was officially keyed as Option A (Carbonic anhydrase) by the testing authority because of its central role in erythrocyte gas exchange (catalyzing $\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3$), and was subsequently considered for grace marks due to the non-enzymatic nature of oxygen-hemoglobin binding.

Why other options are incorrect:

- **Option B:** Carboxylase enzymes catalyze the addition of carbon dioxide into metabolic substrates, with no role in oxygen transport.
- **Option C:** Oxygenases incorporate oxygen atoms directly into organic substrates during metabolic redox reactions.
- **Option D:** Dehydrogenases catalyze biological oxidation-reduction reactions by transferring hydride ions to electron carriers like NAD^+ or FAD.

Question #61 Key: (B)BIOLOGY
14. Reproduction

Which changes occur in the endometrium during the proliferative phase of menstrual cycle?

CORE CONCEPT & DERIVATION

The ovarian follicular phase produces increasing levels of circulating estrogen, which drives morphological repair of the uterine endometrium.

Formula / Rule / Reaction:

↑ Estrogen (from maturing follicles) → Mitotic proliferation of stromal and glandular cells → Endometrial thickening

Solution:

- During the proliferative (pre-ovulatory) phase (days 6 to 14), estrogen secreted by growing ovarian follicles stimulates rapid mitosis in the basal layer (stratum basale).
- The functional layer (stratum functionale) regenerates, vascularity increases, and the endometrium thickens from approximately 1 mm to 3–5 mm.

Why other options are incorrect:

- **Option A:** Endometrial shedding occurs during the menstrual phase (days 1 to 5) following progesterone withdrawal.
- **Option C:** The endometrium becomes secretory and tortuous under the influence of progesterone during the secretory (luteal) phase (days 15 to 28).
- **Option D:** The endometrium undergoes dynamic morphological changes throughout the normal menstrual cycle.

Question #62 Key: (B)BIOLOGY
03. Enzymes

Transfer of phosphate from one compound to another requires an enzyme called:

CORE CONCEPT & DERIVATION

Enzymes are organized into systematic classes based on the specific chemical group transformations they catalyze.

Formula / Rule / Reaction:**Solution:**

- Transferases (EC 2) are enzymes that catalyze the transfer of a specific functional group (such as a phosphate, methyl, or amino group) from a donor substrate to an acceptor molecule.
- Enzymes that transfer phosphate groups (such as phosphotransferases and kinases) are classified within the transferase family.

Why other options are incorrect:

- **Option A:** Oxidoreductases catalyze oxidation-reduction reactions involving the transfer of electrons or hydrogen atoms.
- **Option C:** Hydrolases catalyze hydrolytic cleavage of chemical bonds (ester, glycosidic, peptide) by adding water.
- **Option D:** Ligases catalyze the joining of two molecules coupled with the hydrolysis of a high-energy pyrophosphate bond in ATP.

Question #63 Key: (A)BIOLOGY
15. Inheritance / Variation & GeneticsLinkage of genes in *Drosophila* was first discovered by:**CORE CONCEPT & DERIVATION**

The chromosome theory of inheritance demonstrated that genes located on the same physical chromosome fail to assort independently.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Thomas Hunt Morgan demonstrated genetic linkage using the fruit fly *Drosophila melanogaster* in the early 1910s.
- He showed that genes for white eyes and miniature wings did not show independent assortment because they are physically linked on the X chromosome.

Why other options are incorrect:

- **Option B:** Alfred Sturtevant was Morgan's student who constructed the first genetic linkage map using recombination frequencies, building on Morgan's discovery.
- **Option C:** Gregor Mendel established the principles of segregation and independent assortment working with *Pisum sativum*, without observing linkage.
- **Option D:** Hugo de Vries was one of the rediscoverers of Mendel's work and proposed the mutation theory of evolution using *Oenothera lamarckiana*.

Question #64 Key: (B)BIOLOGY
07. Circulation / Transport

Which of the following structures prevents blood from flowing back into atria?

CORE CONCEPT & DERIVATION

Atrioventricular (AV) valve cusps act as mechanical one-way check valves that prevent retrograde blood flow into the atria during ventricular contraction.

Formula / Rule / Reaction:

Left AV (Bicuspid/Mitral) + Right AV (Tricuspid) → Systolic Closure → Block retrograde flow into atria

Solution:

- The tricuspid valve (right heart) and bicuspid/mitral valve (left heart) guard the atrioventricular orifices.
- When ventricular pressure exceeds atrial pressure during systole, their fibroelastic cusps appose and close, preventing backflow into the atria.

Why other options are incorrect:

- **Option A:** The aortic and pulmonary semilunar valves prevent backflow of blood from the great elastic arteries into the ventricles during ventricular diastole.
- **Option C:** Chordae tendineae are fibrous cords that anchor the valve leaflets to the papillary muscles, preventing valve eversion rather than forming the valve itself.
- **Option D:** Papillary muscles contract during systole to pull on chordae tendineae and prevent cusp prolapse into the atria.

Question #65 Key: (D)BIOLOGY
03. Enzymes

Which of the following is a characteristic of a non-competitive enzyme inhibitor?

CORE CONCEPT & DERIVATION

Non-competitive inhibition occurs when a modifier binds to a distinct regulatory locus on the enzyme rather than competing for the catalytic active site.

Formula / Rule / Reaction:Non-competitive inhibitor: Binds to allosteric site $\Rightarrow V_{\max} \downarrow, K_m$ remains unchanged**Solution:**

- Non-competitive inhibitors bind reversibly or irreversibly to an allosteric regulatory site located away from the active site.
- This binding alters the three-dimensional conformation of the enzyme, reducing its catalytic activity without blocking substrate binding.

Why other options are incorrect:

- **Option A:** Binding directly to the catalytic active site is the defining characteristic of a competitive inhibitor.
- **Option B:** Increasing substrate concentration overcomes competitive inhibition, but has no effect on non-competitive inhibition.
- **Option C:** Inhibitors decrease reaction velocity; they do not increase catalytic speed.

Question #66 Key: (B)BIOLOGY
06. Digestion/Nutrition

The appendix is attached to which part of large intestine?

CORE CONCEPT & DERIVATION

The vermiform appendix is a narrow, blind-ended lymphoid diverticulum arising from the proximal large intestine.

Formula / Rule / Reaction:Ileocecal junction $\rightarrow$ Caecum $\rightarrow$ Posteromedial wall attachment: Vermiform Appendix**Solution:**

- The vermiform appendix arises from the posteromedial wall of the caecum, approximately 2 to 3 cm inferior to the ileocecal valve.
- It contains dense concentrations of submucosal lymphoid follicles, functioning as a secondary lymphoid organ.

Why other options are incorrect:

- **Option A:** The rectum is the distal pelvic segment of the large intestine terminating at the anal canal.
- **Option C:** The colon (ascending, transverse, descending, and sigmoid segments) continues distal to the caecum.
- **Option D:** The ileum is the terminal segment of the small intestine that joins the large intestine at the ileocecal valve.

Question #67 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

If a male with hemophilia marries a non-carrier female, what is the likelihood of their sons in...

CORE CONCEPT & DERIVATION

Hemophilia A and B are X-linked recessive disorders; male offspring inherit their single X chromosome exclusively from their mother.

Formula / Rule / Reaction:

Parental cross: X^hY (Hemophilic male) $\times$ $X^H X^H$ (Normal homozygous female)
 Offspring: Daughters = $X^H X^h$ (100% carriers); Sons = $X^H Y$ (100% unaffected)

Solution:

- The hemophilic father passes his mutated X^h chromosome to all of his daughters and his normal Y chromosome to all of his sons.
- The non-carrier mother contributes a normal X^H chromosome to every son.
- Therefore, 0% of their male offspring will inherit hemophilia.

Why other options are incorrect:

- **Option A:** A 50% probability in sons occurs when the mother is a heterozygous carrier ($X^H X^h$).
- **Option B:** 100% of sons would inherit the disease only if the mother were fully affected with homozygous hemophilia ($X^h X^h$).
- **Option D:** 25% represents the overall fraction of hemophilic sons in a carrier-mother cross, not a normal-mother cross.

Question #68 Key: (C)BIOLOGY
02. Biomolecules

Which of the following is NOT related to DNA?

CORE CONCEPT & DERIVATION

Nucleic acids contain specific nitrogenous purine and pyrimidine bases that maintain genetic fidelity across replication and transcription.

Formula / Rule / Reaction:

DNA Nitrogenous Bases = Adenine (A), Guanine (G), Cytosine (C), Thymine (T)
 RNA Nitrogenous Bases = Adenine (A), Guanine (G), Cytosine (C), Uracil (U)

Solution:

- Uracil is a pyrimidine base found exclusively in ribonucleic acid (RNA), where it base-pairs with adenine.
- DNA uses thymine (5-methyluracil) instead of uracil, meaning uracil is not a standard constituent of normal DNA.

Why other options are incorrect:

- **Option A:** Adenine is a purine base found in both DNA and RNA, pairing with thymine in DNA.
- **Option B:** Thymine is the characteristic pyrimidine base unique to DNA.
- **Option D:** Guanine is a standard purine base found in DNA, pairing with cytosine via three hydrogen bonds.

Question #69 Key: (A)BIOLOGY
16. Evolution

Why Lamarck is being remembered till today?

CORE CONCEPT & DERIVATION

Jean-Baptiste Lamarck proposed the first comprehensive, testable evolutionary theory linking environmental needs to anatomical adaptation.

Formula / Rule / Reaction:

Lamarckism = Use and Disuse of Organs + Inheritance of Acquired Characteristics

Solution:

- Lamarck published 'Philosophie Zoologique' (1809), proposing that traits acquired during an organism's lifetime could be inherited by its offspring.
- Although August Weismann's germ-plasm theory disproved the inheritance of acquired traits, Lamarck is remembered for proposing a coherent evolutionary framework prior to Darwin.

Why other options are incorrect:

- Option B:** His theory was not universally accepted and was largely rejected following advances in Mendelian genetics.
- Option C:** His mechanisms of inheritance were refuted rather than scientifically accepted.
- Option D:** Evolution by natural selection was formulated by Charles Darwin and Alfred Russel Wallace, not Lamarck.

Question #70 Key: (A)BIOLOGY
12. Nervous Coordination

Which of the following neurons conduct impulses from sensory receptors to CNS?

CORE CONCEPT & DERIVATION

Neurons are classified functionally by the direction in which they transmit action potentials relative to the central nervous system (CNS).

Formula / Rule / Reaction:

Peripheral Sensory Receptors $\xrightarrow{\text{Sensory (Afferent) Neurons}}$ Central Nervous System (Brain/Spinal cord)

Solution:

- Sensory (afferent) neurons possess specialized sensory endings or are linked to sensory receptors.
- They convert external and internal environmental stimuli into electrical action potentials and conduct them centripetally into the CNS.

Why other options are incorrect:

- Option B:** Motor neurons conduct impulses away from the CNS to peripheral effector organs (muscles and glands).
- Option C:** Efferent neurons are identical to motor neurons, transmitting signals centrifugally away from the CNS.
- Option D:** Interneurons (association neurons) are confined entirely within the CNS, integrating incoming sensory signals and directing motor output.

Question #71 Key: (C)BIOLOGY
02. Biomolecules

Guanine-cytosine pairs enhance DNA stability due to:

CORE CONCEPT & DERIVATION

The thermal and thermodynamic stability of the DNA double helix is determined by base pairing and base-stacking interactions.

Formula / Rule / Reaction:

A = T (2 Hydrogen Bonds) vs. G = C (3 Hydrogen Bonds)

Solution:

- Guanine pairs with cytosine via three intermolecular hydrogen bonds, whereas adenine pairs with thymine via two hydrogen bonds.
- The higher number of hydrogen bonds in G-C pairs provides greater thermal stability, requiring more energy to denature the double helix.

Why other options are incorrect:

- Option A:** Overall purine-pyrimidine base-pair dimensions are kept uniform within the DNA backbone to maintain a constant 2.0 nm diameter.
- Option B:** The helical geometry and glycosidic bond angles keep the base-pair separation distance constant across all pairs.
- Option D:** Guanine is a double-ringed purine, but cytosine is a single-ringed pyrimidine.

Question #72 Key: (A)BIOLOGY
10. Homeostasis

Which of the following substances pass through the glomerulus into Bowman's capsule?

CORE CONCEPT & DERIVATION

The glomerular filtration barrier acts as a size-selective and charge-selective molecular sieve.

Formula / Rule / Reaction:

Glomerular filtrate = Plasma - [Formed elements + High molecular weight proteins (> 69 kDa)]

Solution:

- The filtration membrane (fenestrated capillary endothelium, basement membrane, and podocyte slit diaphragms) permits water and small dissolved solutes to pass freely.
- Glucose (molecular weight 180 Da) filters freely into Bowman's capsule, yielding an initial tubular concentration identical to that in blood plasma.

Why other options are incorrect:

- Option B:** Red blood cells are cellular elements measuring approximately 7 to 8 micrometers, far too large to traverse intact filtration slits.
- Option C:** Platelets are cellular fragments that cannot cross the intact glomerular basement membrane.
- Option D:** Serum albumin is restricted by both its molecular size (66.5 kDa) and its negative electrostatic charge, which is repelled by anionic heparan sulfate proteoglycans in the basement membrane.

Question #73 Key: (B)BIOLOGY
10. Homeostasis

Shivering thermogenesis involves:

CORE CONCEPT & DERIVATION

Homeostatic thermoregulation relies on metabolic heat production driven by somatic motor reflex pathways.

Formula / Rule / Reaction:Cold exposure → Preoptic anterior hypothalamus → Reticulospinal pathways → Involuntary oscillatory muscle contractions (shivering) → Heat production
Chloroform (Trichloromethane) $\approx 9.0 \text{ kcal/g}$ (37.7 kJ/g); Carbohydrates/Proteins $\approx 4.0 \text{ kcal/g}$ (16.7 kJ/g)**Solution:**

- When core body temperature falls below the hypothalamic set-point, shivering centers in the posterior hypothalamus are activated.
- This triggers rapid, asynchronous, involuntary rhythmic contractions of skeletal muscle motor units, converting ATP hydrolysis into heat.

Why other options are incorrect:

- Option A:** Shivering is an involuntary, subcortically controlled homeostatic reflex, not a voluntary motor act.
- Option C:** Dehydration impairs peripheral perfusion and thermoregulation rather than acting as a mechanism of thermogenesis.
- Option D:** Hormone-mediated heat production (such as thyroxine and catecholamine release) represents non-shivering thermogenesis, particularly in brown adipose tissue.

Question #74 Key: (A)BIOLOGY
08. Immunity

The best way to avoid AIDS is:

CORE CONCEPT & DERIVATION

Epidemiological management of non-curable viral infections relies on interrupting transmission pathways.

Formula / Rule / Reaction:Prevention: Safe screening of blood + Sterile needles + Barrier protection $\Rightarrow$ Block HIV transmission**Solution:**

- Because Human Immunodeficiency Virus (HIV) rapidly mutates its envelope glycoproteins, no effective preventive vaccine exists.
- Strict preventive measures (screening blood products, avoiding reuse of unsterilized syringes, using barrier protection) are the primary defense against infection.

Why other options are incorrect:

- Option B:** There is no approved, effective preventive prophylactic vaccine for HIV/AIDS.
- Option C:** Antiretroviral therapy (ART) suppresses viral load in infected patients, but does not substitute for primary prevention in uninfected populations.
- Option D:** 'Shots' refers colloquially to injections or vaccines, neither of which exists as a universal prophylactic against HIV.

Question #75 Key: (B)BIOLOGY
02. Biomolecules

Which of the following biological molecules releases highest energy from its one gram?

CORE CONCEPT & DERIVATION

The energy density of a macronutrient is determined by the oxidation state of its constituent carbon atoms.

Formula / Rule / Reaction:Chloroform (Trichloromethane) $\approx 9.0 \text{ kcal/g}$ (37.7 kJ/g); Carbohydrates/Proteins $\approx 4.0 \text{ kcal/g}$ (16.7 kJ/g)**Solution:**

- Lipids contain long, highly reduced hydrocarbon chains with a high ratio of carbon-hydrogen bonds and very few oxygen atoms.
- Complete metabolic oxidation of one gram of lipid yields approximately 9 kcal, more than double that of carbohydrates or proteins.

Why other options are incorrect:

- Option A:** Carbohydrates are partially oxidized and yield approximately 4 kcal per gram.
- Option C:** Proteins also yield approximately 4 kcal per gram upon complete combustion.
- Option D:** Water is an inorganic molecule that provides zero chemical caloric energy.

Question #76 Key: (B)BIOLOGY
05. Cellular Life

Which group of viruses can cause diseases like influenza, measles, and rabies?

CORE CONCEPT & DERIVATION

Viruses exhibit specific host tropism, categorized by the phylogenetic domain of the hosts they infect.

Formula / Rule / Reaction:

Animal Viruses: Orthomyxoviridae (Influenza), Paramyxoviridae (Measles), Rhabdoviridae (Rabies)

Solution:

- Influenza, measles, and rabies are all caused by enveloped RNA viruses that infect vertebrate animal cells.
- These pathogens are classified as animal viruses based on their host range and surface glycoproteins.

Why other options are incorrect:

- Option A:** Plant viruses (e.g., Tobacco mosaic virus) infect plant cells, typically using insect vectors to penetrate cellulose cell walls.
- Option C:** Fungal viruses (mycoviruses) infect fungi.
- Option D:** Bacteriophages specifically infect bacterial prokaryotic cells.

Question #77 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

If a disease is caused due to a defective gene located on the X chromosome, then the defective ...

CORE CONCEPT & DERIVATION

Sex chromosome transmission determines the inheritance pattern of sex-linked traits in humans.

Formula / Rule / Reaction:Male Karyotype = 46, XY $\Rightarrow$ X chromosome inherited from ovum (mother), Y from sperm (father)**Solution:**

- Human males inherit their single X chromosome exclusively from their mother via the secondary oocyte (female gamete).
- The father contributes a Y chromosome to male offspring. Therefore, any X-linked gene in a male must originate from the female gamete.

Why other options are incorrect:

- Option B:** The male gamete (spermatozoon) supplies the Y chromosome to make the offspring male, so it cannot pass an X-linked gene to a son.
- Option C:** Bacteria are independent prokaryotic organisms that do not participate in human germline gametogenesis.
- Option D:** While a new mutation can generate a defective allele, the biological vehicle transmitting the chromosome is the female gamete.

Question #78 Key: (B)BIOLOGY
11. Support & Movement

Which of the following surrounds myofibril in skeletal muscle that stores and distributes calci...

CORE CONCEPT & DERIVATION

Excitation-contraction coupling relies on internal membranous networks that store and release calcium ions.

Formula / Rule / Reaction:Action Potential → Depolarization of T-tubules → SERCA release from Sarcoplasmic Reticulum → ↑ $[Ca^{2+}]_{\text{sarcoplasm}}$ **Solution:**

- The sarcoplasmic reticulum is a specialized smooth endoplasmic reticulum that forms a tubular sleeve surrounding individual myofibrils.
- Its terminal cisternae store calcium ions (bound to calsequestrin) and release them into the sarcoplasm to trigger cross-bridge cycling upon muscle stimulation.

Why other options are incorrect:

- **Option A:** The sarcolemma is the outer plasma membrane of the muscle fiber, not an internal calcium-sequestering sleeve.
- **Option C:** Transverse tubules (T-tubules) are invaginations of the sarcolemma that conduct electrical action potentials into the interior of the fiber.
- **Option D:** The sarcoplasm is the fluid cytoplasmic matrix filling the space between myofibrils.

Question #79 Key: (B)BIOLOGY
02. Biomolecules

Water can circulate in living organisms due to:

CORE CONCEPT & DERIVATION

The cohesion-tension theory explains how fluids move through vascular conduits against gravity in biological systems.

Formula / Rule / Reaction:

Cohesion (Water-Water H-bonds) + Adhesion (Water-Xylem cell wall attraction) → Continuous transpiration column

Solution:

- Cohesion between adjacent water molecules maintains an unbroken column of water under negative tension within vascular conduits.
- Adhesion between water dipoles and polar hydrophilic cell walls (like xylem cellulose and lignin) prevents the column from breaking, allowing bulk transport through the plant.

Why other options are incorrect:

- **Option A:** Surface tension resists expansion of the liquid surface, which does not drive bulk vascular circulation.
- **Option C:** Water acts as a biological solvent, but solubility alone does not explain long-distance hydraulic transport.
- **Option D:** A wide liquid temperature range provides thermal stability, but does not provide the physical tension required to move fluids.

Question #80 Key: (B)BIOLOGY
01. Cell

What is the chemical composition of chromosomes?

CORE CONCEPT & DERIVATION

Eukaryotic chromosomes consist of chromatin fibers organized into nucleosomal subunits.

Formula / Rule / Reaction:

Chromatin Fiber = DNA (≈ 40%) + Basic Histone Proteins (≈ 60%)

Solution:

- Eukaryotic chromosomes are composed of double-stranded DNA coiled around octamers of basic histone proteins (H2A, H2B, H3, H4) alongside non-histone regulatory proteins.
- This structure compacts long genomic DNA into the cell nucleus while regulating transcription.

Why other options are incorrect:

- **Option A:** Lipids are membrane constituents and do not form the core structural scaffold of chromosomes.
- **Option C:** Carbohydrates do not make up the structural framework of chromosomes.
- **Option D:** This option omits the primary genetic material, DNA.

Question #81 Key: (B)BIOLOGY
06. Digestion/Nutrition

Which part of small intestine is responsible for nutrient absorption?

CORE CONCEPT & DERIVATION

The segments of the small intestine are specialized for sequential enzymatic digestion and nutrient absorption.

Formula / Rule / Reaction:

Villi + Microvilli (Brush Border) → High surface area for nutrient absorption in the Jejunum

Solution:

- The jejunum has prominent circular folds (plicae circulares) and tall villi that create a large surface area for absorption.
- It is the primary site where the bulk of carbohydrates, amino acids, fatty acids, and water-soluble vitamins are absorbed into the bloodstream.

Why other options are incorrect:

- **Option A:** The duodenum focuses mainly on chemical digestion, neutralizing gastric acid and mixing chyme with pancreatic and biliary secretions.
- **Option C:** The ileum absorbs specific molecules like vitamin B12 and bile salts, as well as remaining electrolytes.
- **Option D:** The rectum is part of the large intestine that stores feces prior to defecation.

Question #82 Key: (C)BIOLOGY
Q2. Biomolecules

Name the biomolecule essential for information storage and transmission within cells.

CORE CONCEPT & DERIVATION

Biological information is stored and transmitted through linear sequences of nucleotide monomers.

Formula / Rule / Reaction:DNA (Long-term information archive) $\xrightarrow{\text{Transcription}}$ mRNA (Information messenger) $\xrightarrow{\text{Translation}}$ Proteins**Solution:**

- Nucleic acids (deoxyribonucleic acid and ribonucleic acid) use the sequence of their nitrogenous bases to store genetic instructions.
- DNA archives this information in the genome, while RNA transcribes and transmits it to direct cellular protein synthesis.

Why other options are incorrect:

- **Option A:** Carbohydrates serve primarily as energy storage molecules and structural cellular components.
- **Option B:** Lipids form membrane bilayers and serve as concentrated long-term energy stores.
- **Option D:** Proteins act as catalytic enzymes, structural scaffolds, and transport channels, but do not store the master genetic instructions.

Question #83 Key: (B)BIOLOGY
Q5. Acellular Life

Which of the following is a route of HIV transmission?

CORE CONCEPT & DERIVATION

Human Immunodeficiency Virus (HIV) transmission requires direct contact with infected bodily fluids that can transfer the virus into the recipient's bloodstream.

Formula / Rule / Reaction:Direct blood-to-blood contact via contaminated transfusion $\rightarrow$ 90 to 95% transmission probability per exposure**Solution:**

- Transfusing unscreened, contaminated whole blood or blood products introduces high concentrations of free virions and infected lymphocytes directly into the recipient's circulation.
- This represents one of the most direct and efficient transmission routes for HIV.

Why other options are incorrect:

- **Option A:** HIV is an enveloped, fragile virus that does not persist on environmental surfaces or spread via unhygienic conditions.
- **Option C:** Casual social contact like hand shaking cannot transmit HIV because intact skin provides a complete barrier.
- **Option D:** Sharing living spaces or breathing the same air does not transmit HIV, which is not spread through airborne routes.

Question #84 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

Crossing over involves exchange of genetic material between:

CORE CONCEPT & DERIVATION

Genetic recombination occurs during prophase I of meiosis via the physical exchange of chromosome segments.

Formula / Rule / Reaction:Synapsis (Pachytene) $\rightarrow$ Chiasma formation between non-sister chromatids $\rightarrow$ Genetic Recombination**Solution:**

- During the pachytene stage of prophase I, homologous maternal and paternal chromosomes pair together in synapsis to form a tetrad.
- Endonuclease-mediated breakage and rejoining occur between non-sister chromatids of these homologous chromosomes, resulting in crossing over and novel combinations of alleles.

Why other options are incorrect:

- **Option A:** Exchange between sister chromatids involves genetically identical copies, producing no new combinations of alleles.
- **Option C:** Exchange between non-homologous chromosomes represents a reciprocal chromosomal translocation, which is an abnormal mutation.
- **Option D:** Sister chromatids belong to the same chromosome, not across homologous chromosomes.

Question #85 Key: (C)BIOLOGY
Q8. Immunity

B-lymphocytes are formed and matured in:

CORE CONCEPT & DERIVATION

Primary lymphoid organs are the anatomical sites where lymphocytes originate and undergo antigen-independent maturation.

Formula / Rule / Reaction:Pluripotent Hematopoietic Stem Cell $\xrightarrow{\text{Stroma signaling}}$ Pre-B cell $\xrightarrow{\text{V(D)J Recombination}}$ Mature, naive B-lymphocyte**Solution:**

- In adult humans, B-lymphocytes originate from hematopoietic stem cells in the red bone marrow.
- They also undergo their primary maturation, immunoglobulin gene rearrangement, and central self-tolerance screening within the red bone marrow before migrating to secondary lymphoid tissues.

Why other options are incorrect:

- **Option A:** The fetal liver is the primary site of B-cell development during embryonic life, but this function shifts to the bone marrow after birth.
- **Option B:** The spleen is a secondary lymphoid organ where mature, naive B cells encounter circulating blood-borne antigens.
- **Option D:** The thymus is the primary lymphoid organ where T-lymphocytes undergo maturation and positive/negative selection.

Question #86 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics*Which phenomenon increases the chances of variations?***CORE CONCEPT & DERIVATION**

Meiotic recombination breaks existing linkage groups, generating new allelic combinations in gametes.

Formula / Rule / Reaction:

Crossing Over $\Rightarrow$ Recombinant gametes generated with frequencies up to 50%

Solution:

- Crossing over during pachytene of meiosis I breaks and swaps maternal and paternal chromatid segments.
- This uncouples linked alleles and produces recombinant chromosomes, increasing genetic variation in the resulting offspring.

Why other options are incorrect:

- **Option B:** Complete genetic linkage preserves parental allele combinations, reducing genetic variation.
- **Option C:** Epistasis is an interaction where one gene masks or modifies the phenotypic expression of another gene, without creating new allelic combinations.
- **Option D:** Dominance masks recessive alleles in heterozygotes, hiding variation rather than generating it.

Question #87 Key: (C)BIOLOGY
08. Immunity*When antibodies produced by B-cells kill the antigens then it is called:***CORE CONCEPT & DERIVATION**

Adaptive immunity is split into antibody-mediated defense in fluids and direct cell-mediated destruction.

Formula / Rule / Reaction:

Plasma B cells $\rightarrow$ Immunoglobulins (Antibodies) $\xrightarrow{\text{Neutralisation/Oxyanization}}$ Humoral Immunity

Solution:

- Activated B-lymphocytes differentiate into plasma cells that secrete soluble antibodies into blood, lymph, and interstitial fluids.
- These antibodies bind, neutralize, and promote the destruction of extracellular pathogens, defining the humoral immune response.

Why other options are incorrect:

- **Option A:** Cell-mediated immunity is carried out by cytotoxic T-lymphocytes (CD8+) that directly destroy virus-infected or altered cells.
- **Option B:** Passive immunity involves receiving pre-formed exogenous antibodies (such as via maternal transfer or antivenom), rather than active production by host B cells.
- **Option D:** 'Cells collaborated response' is not a standard immunological term.

Question #88 Key: (A)BIOLOGY
12. Nervous Coordination*Automatic and rapid actions that do not involve the conscious part of brain is:***CORE CONCEPT & DERIVATION**

Somatic motor responses can be mediated through fast, pre-wired neuroanatomical reflex arcs.

Formula / Rule / Reaction:

Stimulus $\rightarrow$ Receptor $\rightarrow$ Afferent Neuron $\rightarrow$ Spinal Cord/Brainstem $\rightarrow$ Efferent Neuron $\rightarrow$ Effector

Solution:

- A reflex action is an automatic, involuntary motor response to a sensory stimulus that does not require conscious cortical processing.
- The signal is integrated directly in the spinal cord or lower brainstem, allowing for rapid protective responses.

Why other options are incorrect:

- **Option B:** Conditioned reflexes (e.g., Pavlov's salivation response) require prior associative learning and past cortical processing.
- **Option C:** Taxes are directional orientation movements of whole motile organisms toward or away from an environmental gradient (e.g., phototaxis).
- **Option D:** A synapse is the anatomical junction between two communicating excitable cells, not an action itself.

Question #89 Key: (C)BIOLOGY
11. Support & Movement*The regulator of muscle contraction, which is released from sarcoplasmic reticulum, is:***CORE CONCEPT & DERIVATION**

Excitation-contraction coupling uses calcium ions as the primary second messenger to initiate sarcomere shortening.

Formula / Rule / Reaction:

Ca^{2+} binds to Troponin C $\rightarrow$ Conformational shift in Tropomyosin $\rightarrow$ Myosin-binding sites exposed on Actin

Solution:

- Upon membrane depolarization, calcium ions are released from terminal cisternae of the sarcoplasmic reticulum into the sarcoplasm through ryanodine receptor channels.
- These calcium ions bind to troponin C, pulling tropomyosin out of the actin groove and allowing myosin heads to form cross-bridges.

Why other options are incorrect:

- **Option A:** Tropomyosin is a filamentous protein that wraps around actin filaments within the myofibril; it is not stored in or released from the sarcoplasmic reticulum.
- **Option B:** Troponin is a heterotrimeric protein complex bound to actin and tropomyosin on the thin filament.
- **Option D:** ATP is synthesized by cellular respiration in mitochondria, providing energy for cross-bridge detachment rather than serving as the stored release trigger in the sarcoplasmic reticulum.

Question #90 Key: (B)BIOLOGY
17. Biotechnology

Role of mRNA in COVID-19 vaccines like Pfizer and Moderna is to:

CORE CONCEPT & DERIVATION

Lipid nanoparticle-encapsulated mRNA vaccines deliver synthetic genetic instructions into host cells to produce a targeted viral antigen in vivo.

Formula / Rule / Reaction:

Synthetic modified mRNA $\xrightarrow{\text{Host ribosomal translation}}$ SARS-CoV-2 Pre-fusion Spike Protein (Immunogen)

Solution:

- mRNA vaccines deliver nucleoside-modified messenger RNA encoding the SARS-CoV-2 spike glycoprotein into host cells.
- Host cell ribosomes read the mRNA and synthesize the viral spike protein, which is displayed on the cell surface to train B and T cells without using an infectious virus.

Why other options are incorrect:

- Option A:** The mRNA provides the genetic instructions, while the resulting spike protein is what the immune system recognizes.
- Option C:** Naive immune systems do not have pre-existing memory cells for a new pathogen; memory cells form only after exposure to the antigen.
- Option D:** mRNA vaccines deliver genetic transcripts for protein synthesis, not antiviral enzymes.

Question #91 Key: (C)BIOLOGY
11. Support & Movement

Living cells of cartilage are called as:

CORE CONCEPT & DERIVATION

Cartilage is an avascular specialized skeletal connective tissue composed of chondrocytes embedded within an extracellular matrix rich in chondroitin sulfate and collagen.

Formula / Rule / Reaction:

Chondroblasts $\xrightarrow{\text{Matrix secretion and entrapment in lacunae}}$ Chondrocytes (Mature cartilage cells)

Solution:

- Chondrocytes are the mature, living cellular components of cartilage located within small cavities called lacunae.
- They maintain the cartilaginous extracellular matrix by synthesizing collagen fibrils and proteoglycan ground substance.

Why other options are incorrect:

- Option A:** Osteocytes are mature bone cells entombed in mineralized osseous lacunae.
- Option B:** Thrombocytes (platelets) are small, anucleate cytoplasmic fragments in circulating blood involved in hemostasis.
- Option D:** Osteoblasts are active, bone-forming cells responsible for synthesizing bone osteoid matrix.

Question #92 Key: (A)CHEMISTRY
03. Chemical Bonding

Correct order of bond energy will be:

CORE CONCEPT & DERIVATION

Bond dissociation energy in hydrogen halides is inversely proportional to bond length and directly proportional to orbital overlap efficiency.

Formula / Rule / Reaction:

Bond Dissociation Enthalpy: H-Cl (431 kJ/mol) > H-Br (366 kJ/mol) > H-I (299 kJ/mol)

Solution:

- Descending Group 17 (halogens), halogen atomic radius increases significantly: Cl < Br < I.
- Larger internuclear separation results in longer, weaker covalent bonds with poorer orbital overlap with hydrogen 1s, decreasing bond dissociation energy.
- Therefore, the correct decreasing order of bond energy is HCl > HBr > HI.

Why other options are incorrect:

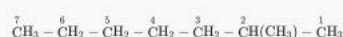
- Option B:** Places HBr higher in bond energy than HCl, which contradicts the shorter, stronger bond in HCl.
- Option C:** Inverts the periodic trend by incorrectly claiming HI has the strongest bond.
- Option D:** Misplaces HI as having higher bond energy than HBr.

Question #93 Key: (A)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

IUPAC name of the compound is CH₃(CH₂)₄CH(CH₃)₂:

CORE CONCEPT & DERIVATION

IUPAC nomenclature of branched alkanes requires selecting the longest continuous carbon chain and numbering from the end closest to the substituent.

Formula / Rule / Reaction:**Solution:**

- Expanding the condensed formula: CH₃ - CH₂ - CH₂ - CH₂ - CH₂ - CH(CH₃)₂.
- The longest continuous carbon chain consists of 7 carbon atoms, identifying the parent alkane as heptane.
- Numbering from the right gives the methyl substituent the lowest possible locant, at carbon-2, yielding 2-methylheptane.

Why other options are incorrect:

- Option B:** Numbering gives a locant of 2, not 3; 3-methylheptane corresponds to an ethyl-branched isomer.
- Option C:** Numbering from the opposite end produces the incorrect, higher locant 6, not 4.
- Option D:** Octane is an unbranched, straight-chain eight-carbon isomer (C₈H₁₈).

Question #94 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic ChemistryIUPAC name of the compound $C_2H_5CH=C(C_3H_7)C_2H_5$ is:

CORE CONCEPT & DERIVATION

For alkenes, the parent chain must be the longest continuous carbon chain containing the carbon-carbon double bond, numbered to give the double bond the lowest locants.

Formula / Rule / Reaction:



Solution:

- Expanding the formula: a 2-carbon ethyl group (C1-C2) connects to CH = (C3), which is double-bonded to carbon-4.
- Carbon-4 bears an ethyl substituent ($-CH_2CH_3$) and continues into a 3-carbon propyl group (C5-C6-C7).
- The longest chain containing the double bond contains 7 carbons (hept-3-ene), with an ethyl branch at C4, giving 4-ethylhept-3-ene.

Why other options are incorrect:

- Option A:** Uses trivial, non-systematic nomenclature based on ethene rather than the longest carbon chain.
- Option B:** Numbers the chain incorrectly, failing to assign locants based on the longest chain direction.
- Option D:** Misplaces the double bond at carbon-2 instead of carbon-3.

Question #95 Key: (A)

CHEMISTRY
18. Carboxylic Acids

Among the following compounds, the most susceptible to nucleophilic attack on the carbonyl carb...

CORE CONCEPT & DERIVATION

The reactivity of carbonyl derivatives toward nucleophilic acyl substitution depends on the magnitude of the partial positive charge on the carbonyl carbon and the leaving group ability.

Formula / Rule / Reaction:

Reactivity Order: Acyl Halide ($RCOCl$) > Acid Anhydride $((RCO)_2O$) > Aldehyde ($RCHO$) > Ester ($RCOOR$)

Solution:

- In acetyl chloride (CH_3COCl), the strongly electronegative chlorine atom withdraws electron density inductively without effective +M resonance donation (due to poor overlap between carbon 2p and chlorine 3p orbitals).
- This maximizes the electrophilicity of the carbonyl carbon, and chloride (Cl^-) acts as a stable, weak-base leaving group.

Why other options are incorrect:

- Option B:** Acetaldehyde lacks a viable leaving group, undergoing nucleophilic addition rather than rapid nucleophilic acyl substitution.
- Option C:** In methyl acetate, strong +M resonance donation from the ester oxygen reduces the electrophilicity of the carbonyl carbon.
- Option D:** Acetic anhydride is reactive, but less electrophilic than an acyl chloride because carboxylate resonance donation partially stabilizes the carbonyl carbon.

Question #96 Key: (D)

CHEMISTRY
12. Transition Elements

Which of the following is expected to be the most paramagnetic?

CORE CONCEPT & DERIVATION

Paramagnetism is directly proportional to the number of unpaired electrons in an atom, governed by Hund's rule of maximum multiplicity.

Formula / Rule / Reaction:

$$\mu_s = \sqrt{n(n+2)} \mu_B \quad (\text{where } n = \text{number of unpaired electrons})$$

Solution:

- ${}_3Li: 1s^2 2s^1$ has $n = 1$ unpaired electron.
- ${}_4Be: 1s^2 2s^2$ has $n = 0$ unpaired electrons (diamagnetic).
- ${}_5B: 1s^2 2s^2 2p^1$ has $n = 1$ unpaired electron.
- ${}_6C: 1s^2 2s^2 2p^1 2p^1$ has $n = 2$ unpaired electrons. Because carbon has the greatest number of unpaired electrons ($n = 2$), it exhibits the highest magnetic moment and is the most paramagnetic.

Why other options are incorrect:

- Option A:** Lithium possesses only 1 unpaired electron, resulting in a lower magnetic moment ($\mu_s = 1.73 \mu_B$).
- Option B:** Beryllium has fully paired subshells and is diamagnetic ($\mu_s = 0$).
- Option C:** Boron contains only 1 unpaired electron in its 2p subshell.

Question #97 Key: (B)

CHEMISTRY
08. Reaction Kinetics

The formation of activated complex in a reaction is:

CORE CONCEPT & DERIVATION

According to transition state theory, reacting molecules must absorb energy to overcome the activation barrier and form the high-energy activated complex.

Formula / Rule / Reaction:



Solution:

- The activated complex resides at the maximum potential energy point along the reaction coordinate.
- Moving from the reactant ground state to this transition state requires an input of activation energy (E_a) to stretch and distort existing bonds.
- Because energy is absorbed, the formation of the activated complex is an endothermic process.

Why other options are incorrect:

- Option A:** Exothermic processes release energy; the transition state cannot form with an overall release of energy relative to reactants.
- Option C:** The transition state lies at a higher potential energy level than the reactants in all chemical reactions, meaning its formation is never exothermic.
- Option D:** Energy is released when the activated complex collapses into products, not during its initial assembly from reactants.

Question #98 Key: (C)

CHEMISTRY
Q2. Atomic Structure

The maximum probability of finding an electron is at a distance of:

CORE CONCEPT & DERIVATION

Radial probability density functions describe the spatial probability of locating an electron at a radial distance r from the nucleus.

Formula / Rule / Reaction:

$$r_1 = a_0 = \frac{4\pi\epsilon_0\hbar^2}{m_e e^2} = 0.529 \text{ \AA} = 0.0529 \text{ nm} \approx 0.053 \text{ nm}$$

Solution:

- For the 1s ground state of atomic hydrogen, the radial probability distribution function $P(r) = 4\pi r^2 [R_{10}(r)]^2$ reaches its maximum at the Bohr radius (a_0).
- The value of a_0 is $0.529 \times 10^{-10} \text{ m} = 0.0529 \text{ nm}$, which rounds to 0.053 nm.

Why other options are incorrect:

- Option A:** 0.53 nm is an order of magnitude too large (5.3 Å).
- Option B:** 0.35 nm does not correspond to any calculated physical shell radius in hydrogen.
- Option D:** 0.0053 nm is an order of magnitude too small (0.053 Å).

Question #99 Key: (A)

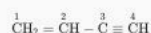
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The IUPAC name of Vinyl acetylene is:

CORE CONCEPT & DERIVATION

When a hydrocarbon contains both a double bond and a triple bond, the chain is numbered to give the lowest possible locants to unsaturations; ties are broken in favor of the double bond.

Formula / Rule / Reaction:



Solution:

- Vinyl acetylene has the structure $\text{CH}_2 = \text{CH} - \text{C} \equiv \text{CH}$.
- Numbering from left to right gives locants 1 (ene) and 3 (yne). Numbering from right to left gives 1 (yne) and 3 (ene).
- In case of identical locant sets (1, 3), IUPAC priority rules give the lower locant to the double bond, yielding But-1-en-3-yne.

Why other options are incorrect:

- Option B:** But-3-en-1-yne violates the tie-breaking priority rule that assigns the lower locant to the double bond.
- Option C:** Vinyl acetylene contains 4 carbon atoms, not 5 (pent).
- Option D:** Contains 5 carbon atoms and misassigns both the chain length and locants.

Question #100 Key: (D)

CHEMISTRY
Q2. Atomic Structure

Which atom has at least single electron in dumbbell shape orbital?

CORE CONCEPT & DERIVATION

Atomic orbitals are characterized by angular momentum quantum numbers: s -orbitals are spherical ($l = 0$), while p -orbitals have dumbbell shapes ($l = 1$).

Formula / Rule / Reaction:



Solution:

- The dumbbell-shaped orbital corresponds to the p subshell ($l = 1$).
- Hydrogen, helium, and lithium fill only spherical s -orbitals.
- Boron (atomic number 5) has the configuration $1s^2 2s^2 2p^1$, containing its fifth electron in a dumbbell-shaped $2p$ orbital.

Why other options are incorrect:

- Option A:** Hydrogen has a single electron residing in a spherical $1s$ orbital.
- Option B:** Helium has two electrons filling a spherical $1s$ orbital.
- Option C:** Lithium has three electrons occupying spherical $1s$ and $2s$ orbitals.

Question #101 Key: (A)

CHEMISTRY
20. Industrial Chemistry

Which of following adhesive is used to bond broken pieces of jewelry?

CORE CONCEPT & DERIVATION

Cyanoacrylate synthetic adhesives cure rapidly via anionic polymerization initiated by trace ambient moisture, providing high tensile bonding strength for non-porous materials.

Formula / Rule / Reaction:



Solution:

- Super glue (cyanoacrylate) forms rapid, high-strength bonds on smooth, non-porous surfaces like metals, gemstones, and ceramics found in jewelry.
- Its fast set time and clear cure make it standard for quick, precise jewelry repairs.

Why other options are incorrect:

- Option B:** Epoxy resins provide high structural strength, but require manual two-part mixing and extended curing times that are less practical for delicate jewelry pieces.
- Option C:** Silicone resins cure into flexible, rubbery elastomers with low tensile bond strength, unsuitable for rigid metal-to-gemstone jewelry repair.
- Option D:** Starch is a water-soluble carbohydrate paste used for paper and cardboard bonding, lacking adhesion for metals and stones.

Question #102 Key: (A)

CHEMISTRY
03. Chemical Bonding

Ratio of sigma bonds and pi bonds present in benzene are:

CORE CONCEPT & DERIVATION

Covalent bond counting in aromatic planar molecules accounts for both ring-forming bonds and peripheral carbon-hydrogen bonds.

Formula / Rule / Reaction:



Solution:

- Benzene possesses 6 carbon-carbon σ bonds in the hexagonal ring and 6 peripheral carbon-hydrogen σ bonds, totaling 12 σ bonds.
- The delocalized aromatic sextet contains 3 π bonds (equivalent to three conjugated double bonds).
- The ratio of σ to π bonds is 12 : 3 = 4 : 1.

Why other options are incorrect:

- **Option B:** 1:4 inverts the ratio, placing pi bonds over sigma bonds.
- **Option C:** 2:3 fails to account for the six carbon-hydrogen sigma bonds.
- **Option D:** 6:1 counts only the six carbon-carbon sigma bonds and omits all carbon-hydrogen bonds (6:1 vs 12:3).

Question #103 Key: (A)

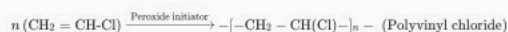
CHEMISTRY
20. Industrial Chemistry

Which one is addition polymer?

CORE CONCEPT & DERIVATION

Addition (chain-growth) polymerization involves the repeated addition of unsaturated monomers containing multiple bonds without forming small-molecule byproducts.

Formula / Rule / Reaction:



Solution:

- Polyvinyl chloride (PVC) is synthesized by the free-radical addition polymerization of vinyl chloride monomers without the loss of any small molecules.
- The empirical formula of the polymer matches that of the monomer, which is the defining characteristic of an addition polymer.

Why other options are incorrect:

- **Option B:** Nylon 6,6 is a step-growth condensation polymer formed by the reaction of adipic acid and hexamethylenediamine, releasing water.
- **Option C:** Nylon 6,10 is a condensation copolymer of sebacoyl chloride (or sebacic acid) and hexamethylenediamine.
- **Option D:** Polyester (e.g., Dacron/Terylene) is a condensation polymer formed from diacids and dialcohols with the elimination of water or alcohol.

Question #104 Key: (A)

CHEMISTRY
08. Reaction Kinetics

When one mole of a substance is decomposed preferably as compared to evaporation then decomposi...

CORE CONCEPT & DERIVATION

Competing physical and chemical processes follow the kinetic and thermodynamic pathway governed by the lower activation energy barrier.

Formula / Rule / Reaction:

$$\text{If Rate}_{\text{decomp}} > \text{Rate}_{\text{evap}} \implies E_{\text{a(decomp)}} < E_{\text{a(evap)}} \text{ (or } \Delta H_{\text{decomp}} < \Delta H_{\text{evap}})$$

Solution:

- For a chemical compound to decompose before evaporating upon heating, the activation energy required to break its covalent bonds must be lower than the energy required to overcome its intermolecular attractions for vaporization.
- Therefore, the preferential decomposition pathway requires lower energy than evaporation.

Why other options are incorrect:

- **Option B:** If decomposition required higher energy than evaporation, the substance would vaporize into the gas phase intact before decomposing.
- **Option C:** Equal energies would lead to concurrent evaporation and decomposition without preference.
- **Option D:** Chemical thermodynamics allows direct prediction based on relative activation energy and enthalpy values.

Question #105 Key: (B)

CHEMISTRY
08. Reaction Kinetics

At start of reaction:

CORE CONCEPT & DERIVATION

Chemical reaction rates are directly proportional to the active concentrations of reactants according to the rate law.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^m[B]^n \implies \text{At } t = 0, [A] \text{ and } [B] \text{ are maximal} \implies \left(-\frac{d[A]}{dt}\right)_{t=0} \text{ is maximal}$$

Solution:

- At the start of a reaction ($t = 0$), the concentrations of the reactants are at their peak.
- Collision frequency between reactant molecules is highest at this point, maximizing the instantaneous rate of reaction (the initial rate).
- As reactants are consumed, concentration decreases and the instantaneous rate drops continuously over time.

Why other options are incorrect:

- **Option A:** The average rate is evaluated over an extended finite time interval (Δt) and does not describe the specific rate at $t = 0$.
- **Option C:** The instantaneous rate is evaluated at an infinitesimal point in time (dt) and differs from the overall average rate.
- **Option D:** Reaction rates are fastest at the start, not slow.

Question #106 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

During Clemmensen reduction of aldehyde and ketone, carbonyl group into alkane group is carried...

CORE CONCEPT & DERIVATION

The Clemmensen reduction deoxygenates carbonyl groups into methylene groups under acidic conditions.

Formula / Rule / Reaction:



Solution:

- The Clemmensen reduction uses zinc amalgam (Zn/Hg) in refluxing concentrated hydrochloric acid (HCl).
- This system reduces the carbonyl group of aldehydes and ketones directly into a saturated methylene group ($-CH_2-$).

Why other options are incorrect:

- Option A:** Catalytic hydrogenation (H_2/Pd) typically reduces aldehydes and ketones to primary and secondary alcohols, rather than fully reducing them to alkanes.
- Option B:** Lithium aluminum hydride ($LiAlH_4$) is a hydride donor that reduces carbonyls to alcohols.
- Option D:** Hydrazine with potassium hydroxide (NH_2NH_2/KOH) represents the Wolff-Kishner reduction, which operates under basic, rather than acidic, conditions.

Question #107 Key: (A)

CHEMISTRY
01. Stoichiometry

Consider the given reaction:



If 56 g o...

CORE CONCEPT & DERIVATION

Stoichiometric theoretical yield is determined by the limiting reactant, and percentage yield measures synthetic efficiency.

Formula / Rule / Reaction:

$$\text{Moles } n = \frac{m}{M}; \quad \% \text{ Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

Solution:

- Moles of N_2 available: $n(N_2) = \frac{56 \text{ g}}{28 \text{ g/mol}} = 2.0 \text{ mol}$.
- Moles of H_2 available: $n(H_2) = \frac{12 \text{ g}}{2 \text{ g/mol}} = 6.0 \text{ mol}$.
- The stoichiometric ratio is $1 N_2 : 3 H_2$. For 2.0 mol N_2 , exactly $2.0 \times 3 = 6.0 \text{ mol}$ of H_2 is required. The reactants are present in exact stoichiometric balance.
- Theoretical yield of NH_3 : $2.0 \text{ mol } N_2 \times 2 = 4.0 \text{ mol } NH_3$.

$$\text{Theoretical Mass} = 4.0 \text{ mol} \times 17 \text{ g/mol} = 68.0 \text{ g}$$

$$\% \text{ Yield} = \frac{51.0 \text{ g}}{68.0 \text{ g}} \times 100 = 75\%$$

Why other options are incorrect:

- Option B:** Calculates theoretical yield based on only 1 mole of nitrogen (34 g).
- Option C:** Calculates the percentage yield incorrectly as 33% instead of 75%.
- Option D:** Underestimates the theoretical yield by half (34 g instead of 68 g).

Question #108 Key: (B)

CHEMISTRY
10. Electrochemistry

When SHE is connected with Cu electrode using salt bridge and external wire:

CORE CONCEPT & DERIVATION

In an electrochemical galvanic cell, the half-cell with the more positive standard reduction potential undergoes reduction at the cathode.

Formula / Rule / Reaction:

$$E^\circ(Cu^{2+}/Cu) = +0.34 \text{ V}; \quad E^\circ(H^+/H_2) = 0.00 \text{ V}$$

$$\text{Cathode (Reduction): } Cu_{(aq)}^{2+} + 2 e^- \rightarrow Cu_{(s)}$$

Solution:

- Copper has a more positive standard reduction potential (+0.34 V) than the standard hydrogen electrode (0.00 V).
- Therefore, the copper half-cell acts as the cathode, where copper(II) cations in solution (Cu^{2+}) accept electrons and are reduced to solid copper.

Why other options are incorrect:

- Option A:** Solid copper metal (Cu^0) is already in its reduced metallic state and cannot be reduced further under these conditions.
- Option C:** Hydride ions (H^-) are not present in aqueous acid solutions.
- Option D:** Gaseous hydrogen (H_2) is oxidized at the anode ($H_2 \rightarrow 2H^+ + 2e^-$), not reduced.

Question #109 Key: (A)

CHEMISTRY
06. Solids

The ionic compound among the following with the highest lattice energy is:

CORE CONCEPT & DERIVATION

Lattice energy in an ionic crystal is directly proportional to ionic charge product and inversely proportional to internuclear separation distance.

Formula / Rule / Reaction:

$$U_0 \propto \frac{|z_+ z_-|}{r_+ + r_-}$$

Solution:

- All four compounds consist of univalent ions ($z_+ = +1, z_- = -1$), making the internuclear distance ($r_+ + r_-$) the determining factor.
- Lithium (Li^+) has the smallest cation radius and fluoride (F^-) has the smallest anion radius among the choices.
- This produces the shortest internuclear distance and the strongest electrostatic attraction, giving LiF the highest lattice energy (approximately 1036 kJ/mol).

Why other options are incorrect:

- Option B:** $NaCl$ has larger ionic radii ($r_{Na^+} + r_{Cl^-}$), yielding a lower lattice energy (786 kJ/mol).
- Option C:** KCl contains larger potassium and chloride ions, with a lattice energy of 715 kJ/mol.
- Option D:** CsI combines the largest alkali cation with the largest halide anion, giving it the lowest lattice energy (600 kJ/mol).

Question #110 Key: (B)

CHEMISTRY
19. Macromolecules / Biochemistry

Digestion of protein started when food enters in:

CORE CONCEPT & DERIVATION

Protein digestion requires an acidic environment to denature native protein structures and activate proteolytic zymogens.

Formula / Rule / Reaction:



Solution:

- Protein digestion begins in the stomach, where parietal cells secrete hydrochloric acid (pH 1.5 – 2.0) and chief cells secrete pepsinogen.
- Acid denatures dietary proteins, and active pepsin cleaves internal peptide bonds, breaking proteins down into smaller proteoses and peptones.

Why other options are incorrect:

- Option A:** Saliva in the mouth contains salivary amylase (ptyalin) for carbohydrate digestion, but lacks endopeptidase enzymes.
- Option C:** The small intestine continues and completes protein digestion via pancreatic trypsin and chymotrypsin, but does not initiate it.
- Option D:** The epiglottis is a cartilaginous flap that protects the airway during swallowing, with no digestive function.

Question #111 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which compound will not show geometrical isomerism?

CORE CONCEPT & DERIVATION

Geometrical (cis-trans) isomerism requires restricted bond rotation and two different substituent groups attached to each unsaturated or ring carbon atom.

Formula / Rule / Reaction:



Solution:

- In pent-1-ene ($\text{CH}_2 = \text{CH} - \text{CH}_2\text{CH}_2\text{CH}_3$), the terminal carbon (C1) carries two identical hydrogen atoms.
- Swapping these identical hydrogens produces an indistinguishable spatial orientation, meaning pent-1-ene cannot exhibit geometrical isomerism.

Why other options are incorrect:

- Option A:** But-2-ene ($\text{CH}_3\text{CH} = \text{CHCH}_3$) has a hydrogen and a methyl on each alkene carbon, forming distinct cis and trans isomers.
- Option B:** 1,2-dimethylcyclopropane possesses a rigid ring with two different substituents on C1 and C2, showing cis-trans isomerism.
- Option D:** 1,3-dimethylcyclopentane exhibits cis and trans isomerism across its ring plane.

Question #112 Key: (A)

CHEMISTRY
05. Liquids

Which of the following is least volatile?

CORE CONCEPT & DERIVATION

Volatility is inversely related to boiling point and the strength of intermolecular attractions, particularly extensive hydrogen bonding.

Formula / Rule / Reaction:



Solution:

- Glycerol ($\text{C}_3\text{H}_8\text{O}_3$) contains three hydroxyl groups per molecule and a high molecular weight (92 g/mol).
- This forms a dense, three-dimensional network of intermolecular hydrogen bonds, resulting in high viscosity, a very low vapor pressure, and a high boiling point (290°C), making it the least volatile.

Why other options are incorrect:

- Option B:** Water boils at 100°C and has a higher vapor pressure than glycerol at room temperature.
- Option C:** Acetic acid forms dimeric hydrogen-bonded pairs, boiling at 118°C.
- Option D:** Diethyl ether has weak dipole-dipole interactions, boiling at 34.6°C, making it highly volatile.

Question #113 Key: (A)

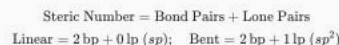
CHEMISTRY
03. Chemical Bonding

All of following have two bond pairs and show linear geometry except:

CORE CONCEPT & DERIVATION

Molecular geometry is determined by the total number of bonding electron pairs and non-bonding lone pairs around the central atom according to VSEPR theory.

Formula / Rule / Reaction:



Solution:

- Tin in SnCl_2 belongs to Group 14 and has 4 valence electrons. It forms 2 single bonds with chlorine and retains 1 non-bonding lone pair.
- This gives a steric number of 3 (sp^2 hybridization), producing an angular or bent geometry (bond angle $\approx 95^\circ$), not linear.

Why other options are incorrect:

- Option B:** Carbon disulfide ($\text{S} = \text{C} = \text{S}$) has 2 double-bond domains and zero lone pairs on carbon (sp, linear, 180°).
- Option C:** Hydrogen cyanide ($\text{H} - \text{C} \equiv \text{N}$) has 2 bond domains and zero lone pairs on carbon (sp, linear, 180°).
- Option D:** Carbon dioxide ($\text{O} = \text{C} = \text{O}$) has 2 bond domains and zero lone pairs on carbon (sp, linear, 180°).

Question #114 Key: (D)

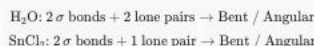
CHEMISTRY
03. Chemical Bonding

Which of the following molecules have similar molecular shape?

CORE CONCEPT & DERIVATION

VSEPR geometry depends on the spatial distribution of terminal atoms, which is shaped by lone-pair repulsions.

Formula / Rule / Reaction:



Solution:

- H_2O has two bonding pairs and two lone pairs on oxygen, producing an angular (bent) molecular geometry.
- SnCl_2 has two bonding pairs and one lone pair on tin, also producing an angular (bent) molecular geometry.
- Therefore, both molecules share a similar bent molecular shape.

Why other options are incorrect:

- **Option A:** NH_3 is trigonal pyramidal, whereas AlCl_3 is trigonal planar.
- **Option B:** BCl_3 is trigonal planar, whereas NH_3 is trigonal pyramidal.
- **Option C:** AlCl_3 is trigonal planar, whereas PCl_3 is trigonal pyramidal.

Question #115 Key: (D)

CHEMISTRY
03. Chemical Bonding

Value of electronegativity of atoms A and B are 1.20 and 4.0 respectively, the percent ionic ch...

CORE CONCEPT & DERIVATION

The partial ionic character of a covalent bond depends on the absolute electronegativity difference between the bonded atoms.

Formula / Rule / Reaction:

$$\% \text{ Ionic Character} = 16 |\Delta\chi| + 3.5 (|\Delta\chi|)^2 \quad (\text{Hannay-Smith Equation})$$

Solution:

- The electronegativity difference is:
- $$\Delta\chi = \chi_B - \chi_A = 4.00 - 1.20 = 2.80$$
- Applying the relation:
- $$\% \text{ Ionic Character} = 16(2.80) + 3.5(2.80)^2 = 44.8 + 3.5(7.84) = 44.8 + 27.44 = 72.24\% \approx 73\%$$
- This large difference of 2.80 yields approximately 73% ionic character.

Why other options are incorrect:

- **Option A:** 43% corresponds to an electronegativity difference of approximately 1.7.
- **Option B:** 50% corresponds to an electronegativity difference of approximately 1.9 to 2.0.
- **Option C:** 55% corresponds to an electronegativity difference of approximately 2.1.

Question #116 Key: (B)

CHEMISTRY
16. Alcohols & Phenols

Phenol differs from ethanol because it:

CORE CONCEPT & DERIVATION

The relative acidity of an organic compound is determined by the thermodynamic stability and charge delocalization of its conjugate base.

Formula / Rule / Reaction:



Solution:

- Loss of a proton from phenol yields the phenoxide anion, where the negative charge on oxygen is delocalized into the aromatic ring across the ortho and para positions.
- In contrast, the ethoxide anion from ethanol cannot delocalize its charge and is destabilized by the electron-donating inductive effect of the ethyl group.
- Consequently, phenol is roughly one million times more acidic than ethanol.

Why other options are incorrect:

- **Option A:** The aromatic ring does not form stronger hydrogen bonds than aliphatic chains.
- **Option C:** The phenolic carbon-oxygen bond has partial double-bond character due to resonance, resisting nucleophilic substitution.
- **Option D:** Phenol is moderately soluble in water (approximately 8.3 g/100 mL) because its hydroxyl group forms hydrogen bonds with water.

Question #117 Key: (B)

CHEMISTRY
14. HydrocarbonsWhich reagent and condition are used to bring about the reaction shown? $\text{C}_6\text{H}_5\text{CH}_3 \xrightarrow{\text{Cl}_2, \text{FeCl}_3} \text{C}_6\text{H}_4\text{CH}_3\text{Cl}$

CORE CONCEPT & DERIVATION

Electrophilic aromatic substitution of alkyl-substituted benzenes requires a Lewis acid catalyst to generate the active halonium electrophile.

Formula / Rule / Reaction:



Solution:

- The methyl substituent on toluene is an activating, ortho/para-directing group through hyperconjugation and inductive effects.
- To substitute the aromatic ring, molecular chlorine must be polarized by a Lewis acid catalyst such as AlCl_3 or FeCl_3 to generate the electrophilic chloronium ion (Cl^+), producing *p*-chlorotoluene and *o*-chlorotoluene.

Why other options are incorrect:

- **Option A:** Molecular chlorine in the dark without a Lewis acid catalyst lacks sufficient electrophilicity to react with an aromatic ring.
- **Option C:** Chlorine in the presence of ultraviolet light induces free-radical halogenation of the aliphatic methyl side chain, producing benzyl chloride.
- **Option D:** Hydrochloric acid does not act as an electrophilic chlorinating agent for aromatic rings.

Question #118 Key: (B)

CHEMISTRY
01. Stoichiometry

What is the percentage yield when actual yield and theoretical yield are 2g and 4g respectively...

CORE CONCEPT & DERIVATION

Percentage yield is the ratio of the experimentally recovered product mass to the maximum theoretical yield calculated from stoichiometry.

Formula / Rule / Reaction:

$$\% \text{ Yield} = \frac{\text{Actual Yield (g)}}{\text{Theoretical Yield (g)}} \times 100$$

Solution:

- Substituting the provided experimental values:

$$\% \text{ Yield} = \frac{2 \text{ g}}{4 \text{ g}} \times 100 = 0.50 \times 100 = 50\%$$

Why other options are incorrect:

- Option A:** 25% corresponds to an actual yield of 1 g from a 4 g theoretical yield.
- Option C:** 75% corresponds to an actual yield of 3 g from a 4 g theoretical yield.
- Option D:** 85% corresponds to an actual yield of 3.4 g from a 4 g theoretical yield.

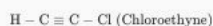
Question #119 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic ChemistryIUPAC name of CHCCl is:

CORE CONCEPT & DERIVATION

Halogenated alkynes are named systematically by identifying the unsaturated carbon chain and adding the halo- prefix to the alkyne parent name.

Formula / Rule / Reaction:



Solution:

- The chemical structure CHCCl represents $\text{H} - \text{C} \equiv \text{C} - \text{Cl}$.
- The parent two-carbon alkyne containing a carbon-carbon triple bond is ethyne.
- With one chlorine substituent, the IUPAC name is chloroethyne.

Why other options are incorrect:

- Option A:** Chloroethane ($\text{CH}_3\text{CH}_2\text{Cl}$) is a saturated alkane containing only single bonds.
- Option C:** Chloroethene (vinyl chloride, $\text{CH}_2 = \text{CHCl}$) contains a double bond rather than a triple bond.
- Option D:** Ethyl chloride is the common name for chloroethane, which is a saturated alkyl halide.

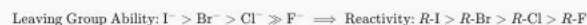
Question #120 Key: (A)

CHEMISTRY
18. Carboxylic AcidsThe order of reactivity of following R-X for $\text{S}_{\text{N}}2$ reaction is:

CORE CONCEPT & DERIVATION

In nucleophilic substitution reactions (both $\text{S}_{\text{N}}1$ and $\text{S}_{\text{N}}2$), the rate-limiting step involves carbon-halogen bond cleavage, governed by leaving group stability and bond strength.

Formula / Rule / Reaction:



Solution:

- The carbon-iodine bond is the weakest and longest among the alkyl halides (bond energy $\approx 238 \text{ kJ/mol}$), while iodide (I^-) is a weak, highly polarizable base and an excellent leaving group.
- In contrast, the carbon-fluorine bond is very strong (bond energy $\approx 467 \text{ kJ/mol}$), and fluoride is a poor leaving group.
- Therefore, the reactivity order for $\text{S}_{\text{N}}2$ displacement is $\text{R-I} > \text{R-Br} > \text{R-Cl} > \text{R-F}$.

Why other options are incorrect:

- Option B:** Incorrectly ranks fluoride as a better leaving group than chloride and iodide.
- Option C:** Places chloride ahead of bromide and iodide, which contradicts leaving group trends.
- Option D:** Inverts the reactivity series by treating the strongest bond (R-F) as the most reactive.

Question #121 Key: (D)

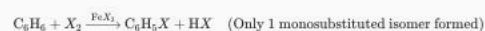
CHEMISTRY
14. Hydrocarbons

Which is not true about benzene:

CORE CONCEPT & DERIVATION

The high structural symmetry of the benzene ring makes all six ring carbon and hydrogen positions chemically equivalent.

Formula / Rule / Reaction:



Solution:

- Because of total resonance delocalization (D_{6h} molecular symmetry), all six CH positions in benzene are chemically identical.
- Monosubstitution yields only one unique chemical compound (e.g., one chlorobenzene), not six distinct constitutional isomers.
- Therefore, the claim that there are '6 sites for monosubstitution' (in the sense of producing different isomers) is false.

Why other options are incorrect:

- Option A:** Each carbon atom in benzene is sp^2 hybridized, forming three planar σ bonds at 120° angles.
- Option B:** Resonance delocalization gives all carbon-carbon bonds an intermediate bond order of 1.5, which is a fractional bond order.
- Option C:** Benzene undergoes electrophilic substitution rather than elimination reactions, which would destroy its stable 6-electron aromatic sextet.

Question #122 Key: (C)

CHEMISTRY
11. S & P Block Elements

If ionization energy of an element is greater then:

CORE CONCEPT & DERIVATION

Metallic character is defined as the ease with which an atom loses valence electrons to form cations (electropositivity).

Formula / Rule / Reaction:



Solution:

- Ionization energy measures the energy required to remove the most loosely bound electron from an isolated gaseous atom.
- A higher ionization energy indicates that the nucleus holds valence electrons more tightly, making cation formation difficult.
- This directly corresponds to reduced electropositivity and lower metallic character.

Why other options are incorrect:

- **Option A:** Strong reducing agents lose electrons readily, which requires a low, not high, ionization energy.
- **Option B:** Electropositivity refers to the tendency to lose electrons, which decreases as ionization energy increases.
- **Option D:** High ionization energy correlates with a smaller atomic radius and higher effective nuclear charge, not a larger radius.

Question #123 Key: (B)

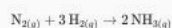
CHEMISTRY
01. Stoichiometry

The mass of hydrogen gas needed to produce 51g ammonia is:

CORE CONCEPT & DERIVATION

Stoichiometric mass calculations use mole ratios from the balanced chemical equation.

Formula / Rule / Reaction:



Solution:

- Molar mass of $\text{NH}_3 = 14 + 3(1) = 17 \text{ g/mol}$.
- Moles of NH_3 to produce:

$$n(\text{NH}_3) = \frac{51 \text{ g}}{17 \text{ g/mol}} = 3.0 \text{ mol}$$
- From the reaction stoichiometry, 2 moles of NH_3 require 3 moles of H_2 :

$$n(\text{H}_2) = 3.0 \text{ mol NH}_3 \times \frac{3 \text{ mol H}_2}{2 \text{ mol NH}_3} = 4.5 \text{ mol H}_2$$
- Mass of $\text{H}_2 = 4.5 \text{ mol} \times 2.0 \text{ g/mol} = 9.0 \text{ g}$

Why other options are incorrect:

- **Option A:** 6 g corresponds to only 3.0 moles of H_2 , producing 34 g of NH_3 .
- **Option C:** 12 g corresponds to 6.0 moles of H_2 , which produces 68 g of NH_3 .
- **Option D:** 15 g exceeds the required stoichiometric amount.

Question #124 Key: (D)

CHEMISTRY
04. Gases

Select the standard condition for temperature and pressure:

CORE CONCEPT & DERIVATION

Standard Temperature and Pressure (STP) is an internationally recognized reference state for gas measurements.

Formula / Rule / Reaction:

$$\text{STP (Classic)} = 0^\circ\text{C} (273.15 \text{ K}) \quad \text{and} \quad 1 \text{ atm} = 760 \text{ mmHg} = 760 \text{ torr} = 14.7 \text{ psi} = 101.325 \text{ kPa}$$

Solution:

- Standard temperature is defined as 0°C (273.15 K).
- Standard pressure is defined as 1 atmosphere, which equals 14.7 pounds per square inch (psi).
- Therefore, Option D accurately pairs standard temperature (0°C) with standard pressure (14.7 psi).

Why other options are incorrect:

- **Option A:** 0 K is absolute zero (-273.15°C), which is not standard temperature.
- **Option B:** 25°C represents standard ambient temperature (SATP), not standard temperature (0°C).
- **Option C:** Combines non-standard pressure (2 bar) with non-standard temperature (25°C).

Question #125 Key: (B)

CHEMISTRY
09. Thermochemistry

Which of the following is NOT a state function?

CORE CONCEPT & DERIVATION

State functions depend only on the current state of a thermodynamic system, whereas path functions depend on the specific pathway taken.

Formula / Rule / Reaction:

$$\oint dX = 0 \Rightarrow X \text{ is a state function } (H, U, P, V, T, S)$$

$$w = - \int P_{\text{ext}} dV \Rightarrow w \text{ is a path function (path-dependent)}$$

Solution:

- Work (w) and heat (q) are boundary phenomena that transfer energy along a specific thermodynamic path.
- Because their values depend on the pathway connecting initial and final states, they are path functions, not state functions.

Why other options are incorrect:

- **Option A:** Enthalpy ($H = U + PV$) is an intrinsic state function whose cyclic integral is zero.
- **Option C:** Internal energy (U) is a state function determined entirely by the temperature and state of the system.
- **Option D:** Pressure (P) is a measurable state variable that describes the current condition of the system.

Question #126 Key: (D)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which one is not a type of stereoisomerism?

CORE CONCEPT & DERIVATION

Stereoisomers share the same connectivity of atoms but differ in three-dimensional spatial arrangement, unlike structural isomers.

Formula / Rule / Reaction:

Isomerism $\rightarrow$ $\begin{cases} \text{Structural (Constitutional): Chain, Positional, Functional, Metamerism, Tautomerism} \\ \text{Stereo: Enantiomers, Diastereomers (Geometrical), Conformational} \end{cases}$

Solution:

- Metamerism is a type of structural (constitutional) isomerism where compounds with the same functional group have unequal distributions of carbon atoms on either side of a polyvalent heteroatom (e.g., $\text{CH}_3\text{OCH}_2\text{CH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$).
- Because it involves differences in atomic connectivity rather than spatial orientation, metamerism is not a form of stereoisomerism.

Why other options are incorrect:

- Option A:** Conformational isomerism arises from rotation about single sigma bonds, representing stereoisomerism.
- Option B:** Optical isomerism involves non-superimposable mirror-image spatial arrangements, representing stereoisomerism.
- Option C:** Geometrical isomerism involves different spatial arrangements of substituents across a restricted double bond or ring, representing stereoisomerism.

Question #127 Key: (A)

CHEMISTRY
18. Carboxylic Acids

Formic acid reacts with ethanol in presence of acid catalyst producing:

CORE CONCEPT & DERIVATION

Fischer esterification is an acid-catalyzed condensation between a carboxylic acid and an alcohol that forms an ester and water.

Formula / Rule / Reaction:



Solution:

- Formic acid (methanoic acid) reacts with ethanol in the presence of concentrated sulfuric acid as a catalyst.
- Nucleophilic acyl substitution by the alcohol oxygen on the protonated carboxylic acid eliminates water, yielding ethyl formate, which is an ester.

Why other options are incorrect:

- Option B:** Ethers are produced by the intermolecular dehydration of two alcohol molecules, not from a carboxylic acid and an alcohol.
- Option C:** Acid anhydrides form through the dehydration of two carboxylic acid molecules.
- Option D:** Phenol is an aromatic hydroxy compound ($\text{C}_6\text{H}_5\text{OH}$) that cannot form from simple aliphatic acids and alcohols.

Question #128 Key: (A)

CHEMISTRY
08. Reaction Kinetics k is called specific rate constant because it is:

CORE CONCEPT & DERIVATION

The specific rate constant k is the rate of a chemical reaction when all reacting species are at unit concentration.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^m[B]^n \Rightarrow \text{If } [A] = [B] = 1.0 \text{ mol/dm}^3, \text{ then Rate} = k$$

Solution:

- By definition, the rate constant k represents the specific reaction velocity when every reactant concentration equals unity (1.0 mol/dm^3).
- This makes it the reaction rate per unit concentration, giving it the name specific rate constant.

Why other options are incorrect:

- Option B:** The rate constant is strongly temperature-dependent, as described by the Arrhenius equation ($k = Ae^{-E_a/RT}$).
- Option C:** The numerical value of k is a constant for a given reaction at a fixed temperature, independent of changing reactant concentrations.
- Option D:** The units of k depend directly on the overall reaction order (e.g., s^{-1} , $\text{dm}^3\text{mol}^{-1}\text{s}^{-1}$), meaning it is rarely unitless.

Question #129 Key: (C)

CHEMISTRY
03. Chemical BondingNumber of sigma bonds in methyl chloride due to sp^3-s overlap is/are:

CORE CONCEPT & DERIVATION

Molecular orbital hybridization identifies the specific atomic and hybrid orbitals involved in localized covalent bonds.

Formula / Rule / Reaction:



Solution:

- In methyl chloride (CH_3Cl), the central carbon atom forms four σ bonds using sp^3 hybrid orbitals.
- Each of the three hydrogen atoms uses its spherical $1s$ orbital to overlap with a carbon sp^3 orbital, forming three $sp^3 - s$ σ bonds.
- The carbon-chlorine bond forms via $sp^3 - 3p$ overlap between carbon and chlorine. Therefore, there are exactly 3 σ bonds formed by $sp^3 - s$ overlap.

Why other options are incorrect:

- Option A:** 1 corresponds to the single carbon-chlorine $sp^3 - 3p$ σ bond.
- Option B:** 2 does not match the three equivalent C-H single bonds.
- Option D:** 4 is the total number of sigma bonds in the molecule, but only three are formed by $sp^3 - s$ overlap.

Question #130 Key: (A)

CHEMISTRY
04. Gases

When pressure is 1520 torr then density of oxygen gas will be:

CORE CONCEPT & DERIVATION

The density of an ideal gas can be derived directly from the ideal gas equation and the molar mass of the gas.

Formula / Rule / Reaction:

$$P = \frac{\rho}{M} RT \Rightarrow \rho = \frac{PM}{RT}$$

Solution:

- Convert pressure from torr to atmospheres:

$$P = \frac{1520 \text{ torr}}{760 \text{ torr/atm}} = 2.0 \text{ atm}$$

- Molar mass of diatomic oxygen gas (O_2): $M = 32.0 \text{ g/mol}$.

- Substitute these values into the density equation:

$$\rho = \frac{PM}{RT} = \frac{(2.0)(32.0)}{RT} = \frac{64}{RT}$$

Why other options are incorrect:

- Option B:** $32/RT$ corresponds to a pressure of 1 atm (760 torr), not 1520 torr.
- Option C:** $16/RT$ corresponds to a pressure of 0.5 atm or uses the atomic weight of oxygen instead of the molecular weight of O_2 .
- Option D:** $128/RT$ corresponds to a pressure of 4 atm (3040 torr).

Question #131 Key: (B)

CHEMISTRY
04. GasesWhich equation is used to calculate concentration for n mole of an ideal gas?

CORE CONCEPT & DERIVATION

Molar concentration (molarity) of a gas is defined as moles of gas per unit volume ($C = n/V$).

Formula / Rule / Reaction:

$$PV = nRT \Rightarrow \frac{n}{V} = \frac{P}{RT} \Rightarrow C = \frac{P}{RT}$$

Solution:

- From the ideal gas equation, $PV = nRT$.

- Rearranging to solve for molar concentration (n/V):

$$\text{Concentration } C = \frac{n}{V} = \frac{P}{RT}$$

- Therefore, the molar concentration of an ideal gas is directly proportional to pressure and inversely proportional to absolute temperature.

Why other options are incorrect:

- Option A:** $PV/RT = n$, which calculates the absolute number of moles, not concentration (n/V).
- Option C:** Contains redundant variables without physical basis in the ideal gas law.
- Option D:** $PM/RT = \rho$, which gives mass density in grams per unit volume, not molar concentration in moles per unit volume.

Question #132 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

Which carbonyl carbon is more electrophilic?

CORE CONCEPT & DERIVATION

The electrophilicity of a carbonyl carbon depends on the magnitude of its partial positive charge, which is reduced by electron-donating inductive and resonance effects.

Formula / Rule / Reaction:

$$\text{Electrophilicity: HCHO} > \text{RCHO} > \text{R}_2\text{CO} > \text{RCOOH}$$

Solution:

- In formaldehyde (HCHO), the carbonyl group is bonded only to two hydrogen atoms, providing zero electron-donating inductive (+I) effect.
- In ketones and carboxylic acids, alkyl groups provide +I donation and hydroxyl groups provide +M resonance donation, reducing the partial positive charge on carbon.
- This leaves formaldehyde with the most electron-deficient, electrophilic carbonyl carbon.

Why other options are incorrect:

- Option A:** In formic acid, +M resonance donation from the lone pairs of the -OH group reduces the electrophilicity of the carbonyl carbon.
- Option C:** In acetone (CH_3COCH_3), two electron-donating methyl groups reduce the electrophilic charge via +I induction and hyperconjugation.
- Option D:** In acetic acid, electron donation from both the methyl group and the hydroxyl group reduces carbonyl electrophilicity.

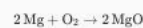
Question #133 Key: (B)

CHEMISTRY
01. Stoichiometry50g of Mg is burnt with 32g of oxygen to form MgO , amount of excess reagent left is?

CORE CONCEPT & DERIVATION

The limiting reagent is completely consumed in a chemical reaction, leaving a calculated unreacted mass of the excess reagent.

Formula / Rule / Reaction:



Solution:

- Moles of reactants supplied:

$$n(\text{Mg}) = \frac{50 \text{ g}}{24 \text{ g/mol}} = 2.083 \text{ mol}; \quad n(\text{O}_2) = \frac{32 \text{ g}}{32 \text{ g/mol}} = 1.00 \text{ mol}$$

- From the balanced reaction, 1.00 mole of O_2 requires exactly 2.00 moles of Mg.

- Because 2.083 moles of Mg are present, oxygen is the limiting reactant and magnesium is in excess:

$$n(\text{Mg})_{\text{reacted}} = 2.00 \text{ mol} \Rightarrow m(\text{Mg})_{\text{reacted}} = 2.00 \text{ mol} \times 24 \text{ g/mol} = 48 \text{ g}$$

$$\text{Excess Mg left} = 50 \text{ g} - 48 \text{ g} = 2 \text{ g Mg}$$

Why other options are incorrect:

- Option A:** 6 g unreacted magnesium is based on an incorrect molar mass or ratio.
- Option C:** Oxygen is the limiting reactant and is completely consumed, leaving 0 g of O_2 .
- Option D:** Incorrectly identifies oxygen as the excess reagent.

Question #134 Key: (B)

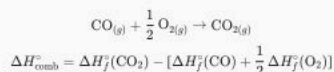
CHEMISTRY
09. Thermochemistry

The heat of formation of CO and CO₂ are -26.4 Kcal and -94.0 Kcal respectively. The heat of com...

CORE CONCEPT & DERIVATION

Hess's Law of constant heat summation states that the enthalpy change of a reaction equals the sum of standard enthalpies of formation of products minus reactants.

Formula / Rule / Reaction:



Solution:

- Given: $\Delta H_f^{\circ}(\text{CO}) = -26.4 \text{ kcal/mol}$, $\Delta H_f^{\circ}(\text{CO}_2) = -94.0 \text{ kcal/mol}$, and $\Delta H_f^{\circ}(\text{O}_2) = 0 \text{ kcal/mol}$ (standard elemental state).
- Applying Hess's law:
- $\Delta H_{\text{comb}}^{\circ} = -94.0 - (-26.4 + 0) = -94.0 + 26.4 = -67.6 \text{ kcal/mol}$

Why other options are incorrect:

- Option A:** +26.4 kcal is simply the reverse of the enthalpy of formation of carbon monoxide.
- Option C:** +94.0 kcal is the energy required to decompose one mole of CO₂ back into its elements.
- Option D:** -120.4 kcal incorrectly adds the magnitudes of both heats of formation (-94.0 - 26.4).

Question #135 Key: (A)

CHEMISTRY
16. Alcohols & Phenols

Rate of dehydration of alcohol is:

CORE CONCEPT & DERIVATION

Acid-catalyzed dehydration of alcohols proceeds through an E1 elimination pathway, where the rate depends on the stability of the intermediate carbocation.

Formula / Rule / Reaction:



Solution:

- The rate-determining step in alcohol dehydration is the loss of water from the protonated alcohol to form a carbocation intermediate.
- Tertiary (3°) carbocations are stabilized by hyperconjugation and +I inductive effects from three adjacent alkyl groups.
- This makes tertiary alcohols dehydrate most rapidly, followed by secondary (2°), with primary (1°) alcohols being the slowest: $3^\circ > 2^\circ > 1^\circ$.

Why other options are incorrect:

- Option B:** Inverts the trend; primary alcohols are the least reactive and require harsh dehydrating conditions (e.g., concentrated H₂SO₄ at 180°C).
- Option C:** Incorrectly places secondary alcohols ahead of tertiary alcohols.
- Option D:** Incorrectly places primary alcohols ahead of secondary alcohols.

Question #136 Key: (B)

PHYSICS
07. Thermodynamics

During the drilling of a metal surface the drill bit heats up. This heat comes from the:

CORE CONCEPT & DERIVATION

The first law of thermodynamics dictates that mechanical work expended against non-conservative dissipative forces converts directly into internal thermal energy.

Formula / Rule / Reaction:

$$W_{\text{friction}} = f_k \cdot d = \Delta U = mc\Delta T$$

Solution:

- As the cutting edges of the drill bit penetrate and shear the metal, mechanical work is done against strong frictional and shear resistance.
- This mechanical work dissipates at the contacting interface as microscopic kinetic vibrational energy of the lattice atoms, raising the temperature of both the bit and the workpiece.

Why other options are incorrect:

- Option A:** Mechanical tool vibrations dissipate negligible acoustic and strain energy compared to contact friction.
- Option C:** Electric current drives the motor inside the drill housing; it does not flow across the mechanical bit-metal cutting interface.
- Option D:** Air compression by the rotating bit produces negligible aerodynamic heating at standard drilling velocities.

Question #137 Key: (A)

PHYSICS
08. Electrostatics

If 2J of work is done in moving two coulombs of charge from one point to the other in an electr...

CORE CONCEPT & DERIVATION

Electric potential difference between two points is defined as the work required per unit positive test charge to move it against an electrostatic field.

Formula / Rule / Reaction:

$$\Delta V = \frac{W}{q}$$

Solution:

- Given work done $W = 2 \text{ J}$ and charge moved $q = 2 \text{ C}$.
- Calculate potential difference:

$$\Delta V = \frac{2 \text{ J}}{2 \text{ C}} = 1 \text{ J/C} = 1 \text{ V}$$

Why other options are incorrect:

- Option B:** 2 J/C incorrectly assumes 4 J of work or a 1 C charge.
- Option C:** 'JC' represents energy multiplied by charge, which is dimensionally incorrect for electric potential.
- Option D:** 4 J/C incorrectly multiplies work by charge instead of dividing.

Question #138 Key: (C)

PHYSICS
05. Waves

The motion of transverse waves involves particle's vibration:

CORE CONCEPT & DERIVATION

Mechanical waves are classified based on the orientation of constituent particle displacement relative to the direction of energy propagation.

Formula / Rule / Reaction:

$$\vec{v}_{\text{propagation}} \perp \vec{\xi}_{\text{oscillation}} \implies \text{Transverse Wave}$$

Solution:

- In a transverse mechanical wave, constituent particles of the transmitting medium oscillate in simple harmonic motion along an axis perpendicular to the direction in which the wave propagates.
- Examples include surface water waves, waves on stretched strings, and electromagnetic waves.

Why other options are incorrect:

- Option A:** Particle vibration parallel to the direction of wave propagation defines longitudinal waves (such as acoustic sound waves).
- Option B:** Particles oscillate symmetrically about equilibrium; they do not travel opposite to energy flow.
- Option D:** Random, uncoordinated molecular motion describes thermal agitation, not a coherent mechanical wave.

Question #139 Key: (A)

PHYSICS
04. Rotational & Circular Motion

A body moving in a circle, half revolution in terms of radians is equivalent:

CORE CONCEPT & DERIVATION

Angular displacement is converted between revolutions, degrees, and radians through standard circular geometric relations.

Formula / Rule / Reaction:

$$1 \text{ complete revolution} = 360^\circ = 2\pi \text{ radians}$$

$$\theta = \frac{1}{2} \times 2\pi = \pi \text{ radians}$$

Solution:

- One complete circle covers an angular displacement of 2π radians.
- For half a revolution:

$$\theta = \frac{2\pi}{2} = \pi \text{ radians}$$

Why other options are incorrect:

- Option B:** $\pi/6$ radians corresponds to 30° or $1/12$ of a complete revolution.
- Option C:** $\pi/2$ radians corresponds to 90° or a quarter of a revolution.
- Option D:** 2π radians represents a full revolution (360°).

Question #140 Key: (B)

PHYSICS
01. Vectors & Equilibrium

If $A = (a\hat{i} + b\hat{j})$ and $B = 4(a\hat{i} - b\hat{j})$, magnitude of $A \times B =$

CORE CONCEPT & DERIVATION

The vector cross product of two planar vectors is calculated using Cartesian component determinants and unit vector properties.

Formula / Rule / Reaction:

$$\vec{A} \times \vec{B} = (A_x B_y - A_y B_x) \hat{k}$$

$$|\vec{A} \times \vec{B}| = |A_x B_y - A_y B_x|$$

Solution:

$$\text{Vector } \vec{A} = a\hat{i} + b\hat{j}.$$

$$\text{Vector } \vec{B} = 4a\hat{i} - 4b\hat{j}.$$

Evaluate the cross product:

$$\vec{A} \times \vec{B} = (a\hat{i} + b\hat{j}) \times (4a\hat{i} - 4b\hat{j})$$

$$= a(-4b)(\hat{i} \times \hat{j}) + b(4a)(\hat{j} \times \hat{i}) = -4ab\hat{k} + 4ab(-\hat{k}) = -8ab\hat{k}$$

Take the absolute magnitude:

$$|\vec{A} \times \vec{B}| = |-8ab| = 8ab$$

Why other options are incorrect:

- Option A:** $4(a^2 + b^2)$ resembles the dot product or sum of squared components, not the cross product magnitude.
- Option C:** Incorrectly factors the scalar product as a sum $8(a + b)$ rather than a product $8ab$.
- Option D:** 0 would require the vectors to be collinear (parallel or anti-parallel), which they are not.

Question #141 Key: (A)

PHYSICS
16. Nuclear Physics

A proton and an alpha particle enter a uniform magnetic field of the same magnitude perpendicular...

CORE CONCEPT & DERIVATION

A charged particle entering a perpendicular magnetic field follows a circular trajectory where the magnetic Lorentz force provides the centripetal acceleration.

Formula / Rule / Reaction:

$$F_B = qvB = \frac{mv^2}{r} \implies r = \frac{mv}{qB}$$

Solution:

$$\text{For a proton: mass } m_p = m, \text{ charge } q_p = e:$$

$$r_p = \frac{mv}{eB}$$

$$\text{For an alpha particle } ({}^4_2\text{He}^{2+}): \text{ mass } m_\alpha = 4m, \text{ charge } q_\alpha = 2e:$$

$$r_\alpha = \frac{4mv}{2eB} = 2 \left(\frac{mv}{eB} \right) = 2r_p$$

- Because $r_\alpha = 2r_p$, the alpha particle traces a circle with twice the radius of the proton, giving it a larger radius and less curvature.

Why other options are incorrect:

- Option B:** The alpha particle's greater mass-to-charge ratio increases its orbital radius, so it cannot be smaller.
- Option C:** 'Smaller path length' does not describe the orbital geometry of continuous circular motion.
- Option D:** Greater deflection requires a tighter turn (smaller radius); because the alpha particle has twice the radius, it undergoes less deflection.

Question #142 Key: (C)PHYSICS
04. Rotational & Circular Motion

In circular motion, if angular displacement is kept constant, decreasing the radius will:

CORE CONCEPT & DERIVATION

Linear distance traversed along a circular arc is directly proportional to both the radius of curvature and the subtended angular displacement.

Formula / Rule / Reaction:

$$s = r \cdot \theta$$

Solution:

- The linear arc displacement is given by $s = r\theta$, where θ is measured in radians.
- If θ is held constant, linear displacement s is directly proportional to radius r ($s \propto r$).
- Therefore, decreasing the radius r directly decreases the resulting linear displacement.

Why other options are incorrect:

- Option A:** Decreasing r reduces arc length, so it cannot increase linear displacement.
- Option B:** Linear velocity depends on angular velocity ($v = r\omega$); decreasing radius at a fixed angular rate decreases linear velocity.
- Option D:** Linear displacement is directly coupled to radius through the arc relation, so it cannot remain unaffected.

Question #143 Key: (B)PHYSICS
03. Work & Energy

When force and displacement are in opposite direction then the work done is said to be:

CORE CONCEPT & DERIVATION

Work done by a constant force is defined by the scalar dot product of the force and displacement vectors.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = Fd \cos(\theta)$$

$$\text{If } \vec{F} \text{ and } \vec{d} \text{ are antiparallel: } \theta = 180^\circ \Rightarrow \cos(180^\circ) = -1 \Rightarrow W = -Fd$$

Solution:

- When force opposes displacement, the angle between the vectors is $\theta = 180^\circ$.
- Because $\cos(180^\circ) = -1$, the calculated work done is negative (such as work done by kinetic friction).

Why other options are incorrect:

- Option A:** Positive work occurs when the angle between force and displacement is acute ($0^\circ \leq \theta < 90^\circ$).
- Option C:** Work done is finite and bounded by the product of force and distance magnitudes.
- Option D:** Maximum positive work occurs when force and displacement are aligned in the same direction ($\theta = 0^\circ$).

Question #144 Key: (D)PHYSICS
11. Electromagnetic Induction

In a step-up transformer, if the secondary voltage is increased by a factor of 10, the current ...

CORE CONCEPT & DERIVATION

Conservation of electrical energy in an ideal transformer dictates that input apparent power equals output apparent power.

Formula / Rule / Reaction:

$$P_p = P_s \Rightarrow V_p I_p = V_s I_s \Rightarrow \frac{I_s}{I_p} = \frac{V_p}{V_s}$$

Solution:

- For an ideal step-up transformer where secondary voltage increases ten-fold:

$$V_s = 10 V_p \Rightarrow \frac{V_p}{V_s} = \frac{1}{10}$$

- Substituting into the power conservation relation:

$$I_s = I_p \left(\frac{V_p}{V_s} \right) = \frac{1}{10} I_p$$

- Thus, the secondary current is reduced to one-tenth of the primary current.

Why other options are incorrect:

- Option A:** Increasing both voltage and current by a factor of 10 would yield a 100-fold increase in power, violating the first law of thermodynamics.
- Option B:** Phrased ambiguously; the standard technical terminology is 'one-tenth of the primary current'.
- Option C:** Current cannot remain equal if voltage changes without altering power transfer.

Question #145 Key: (A)PHYSICS
06. Fluid Dynamics

When a droplet reaches terminal velocity, its acceleration is:

CORE CONCEPT & DERIVATION

Terminal velocity is achieved when opposing hydrodynamic drag forces balance downward gravitational forces, establishing dynamic equilibrium.

Formula / Rule / Reaction:

$$\Sigma F_y = W - F_d = mg - 6\pi\eta r v_t = 0 \Rightarrow a = \frac{\Sigma F_y}{m} = 0$$

Solution:

- As a droplet falls through a viscous fluid, its downward velocity increases, which increases the upward viscous drag force (Stokes' law).
- When the drag force equals the droplet's effective weight, the net external force acting on the droplet becomes zero.
- According to Newton's second law ($F_{\text{net}} = ma$), zero net force results in zero acceleration, and the droplet continues downward at constant terminal speed.

Why other options are incorrect:

- Option B:** Acceleration was variable during the initial transient fall, but becomes fixed at zero once terminal velocity is reached.
- Option C:** 'Not changed' is ambiguous; acceleration drops from 9.8 m/s^2 to zero during the descent.
- Option D:** Negative acceleration would cause the droplet to decelerate, rather than maintaining a constant terminal velocity.

Question #146 Key: (B)

PHYSICS
05. Waves

Newton's original formula underestimated speed of sound in air because he:

CORE CONCEPT & DERIVATION

Newton calculated acoustic wave speed by assuming that compressions and rarefactions occur isothermally with negligible temperature changes.

Formula / Rule / Reaction:

$$v_{\text{Newton}} = \sqrt{\frac{B_{\text{isothermal}}}{\rho}} = \sqrt{\frac{P}{\rho}} \approx 280 \text{ m/s} \quad (\text{Theoretical})$$

$$v_{\text{Laplace}} = \sqrt{\frac{B_{\text{adiabatic}}}{\rho}} = \sqrt{\frac{\gamma P}{\rho}} \approx 332 \text{ m/s} \quad (\text{Experimental})$$

Solution:

- Sir Isaac Newton assumed acoustic pressure oscillations were slow enough for heat to transfer to the surroundings, keeping temperature constant (isothermal condition, where bulk modulus $B = P$).
- This produced a theoretical speed of 280 m/s, underestimating the experimental value of 332 m/s by about 16%.
- Laplace corrected this by recognizing that sound compressions and rarefactions occur too rapidly for heat exchange, behaving as an adiabatic process where $B = \gamma P$.

Why other options are incorrect:

- **Option A:** Air viscosity has a negligible effect on sound speed in open air.
- **Option C:** Newton measured and formulated his equation for air at atmospheric pressure, not vacuum.
- **Option D:** Assuming adiabatic conditions was Laplace's successful correction, not Newton's original assumption.

Question #147 Key: (D)

PHYSICS
08. Electrostatics

The point where the electric field is zero between two opposite charge lies:

CORE CONCEPT & DERIVATION

The net electric field at any point in space is the vector sum of individual electric field contributions from all source charges.

Formula / Rule / Reaction:

$$\vec{E}_{\text{net}} = \vec{E}_+ + \vec{E}_- = \frac{k|q_1|}{r_1^2} \hat{r} + \frac{k|q_2|}{r_2^2} \hat{r} \neq 0 \quad (\text{Between opposite charges})$$

Solution:

- Between two opposite charges (one positive, one negative), the electric field due to the positive charge points away from itself (toward the negative charge).
- The electric field due to the negative charge also points toward itself.
- Because both field vectors point in the same direction along the line connecting the charges, they reinforce each other and can never cancel to zero anywhere between them.

Why other options are incorrect:

- **Option A:** Near the positive charge, both field components point toward the negative charge, so they do not cancel.
- **Option B:** At the midpoint, both field vectors point in the same direction, producing a non-zero vector sum.
- **Option C:** Near the negative charge, both fields continue to point toward the negative charge, so they never sum to zero.

Question #148 Key: (B)

PHYSICS
01. Vectors & Equilibrium

Consider these two vectors $A = 2i + 3j$ and $B = -6i + 4j$. The angle between these two vectors is...

CORE CONCEPT & DERIVATION

The angle between two vectors is determined using their scalar dot product and magnitudes.

Formula / Rule / Reaction:

$$\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}|\cos(\theta) = A_x B_x + A_y B_y$$

Solution:

- Calculate the scalar dot product:
- $\vec{A} \cdot \vec{B} = (2)(-6) + (3)(4) = -12 + 12 = 0$
- Because $\vec{A} \cdot \vec{B} = 0$ and neither vector has zero magnitude:
- $\cos(\theta) = 0 \implies \theta = 90^\circ$
- The vectors are mutually perpendicular.

Why other options are incorrect:

- **Option A:** 0° requires the vectors to be parallel, which requires a positive non-zero dot product equal to the product of their magnitudes.
- **Option C:** 120° would yield a negative dot product equal to $-0.5|\vec{A}||\vec{B}|$.
- **Option D:** 180° requires antiparallel vectors, yielding a dot product of $-|\vec{A}||\vec{B}|$.

Question #149 Key: (C)

PHYSICS
02. Force & Motion

A displacement time graph is a straight line inclined up at angle of 45° with X-axis, velocity ...

CORE CONCEPT & DERIVATION

The first derivative of displacement with respect to time represents instantaneous velocity, corresponding to the slope of a displacement-time graph.

Formula / Rule / Reaction:

$$v = \frac{ds}{dt} = \text{slope} = \tan(\theta)$$

Solution:

- The graph is a straight line, which has a constant slope throughout its length.
- For an inclination angle of $\theta = 45^\circ$, the slope is constant:
- $v = \tan(45^\circ) = 1.0 \text{ m/s}$
- Because the slope does not change with time, the velocity is constant.

Why other options are incorrect:

- **Option A:** An increasing velocity would produce an upward-curving parabolic graph with an increasing slope.
- **Option B:** A decreasing velocity would produce a curve that flattens out over time.
- **Option D:** Fluctuating slopes correspond to curved, non-linear graphs.

Question #150 Key: (A)PHYSICS
03. Work & Energy

A 150 kg car has its velocity reduced from 20 m/s to 10 m/s in 3.0 sec. How large was the average...

CORE CONCEPT & DERIVATION

Average retarding force is calculated by applying Newton's second law to the rate of change of linear momentum.

Formula / Rule / Reaction:

$$a = \frac{v_f - v_i}{\Delta t}; \quad F_{\text{retarding}} = m|a| = m \left| \frac{v_f - v_i}{\Delta t} \right|$$

Solution:

- Calculate deceleration:

$$a = \frac{10 \text{ m/s} - 20 \text{ m/s}}{3.0 \text{ s}} = -\frac{10}{3} \text{ m/s}^2 = -3.33 \text{ m/s}^2$$

- Calculate the retarding force:

$$F = m|a| = 150 \text{ kg} \times \frac{10}{3} \text{ m/s}^2 = 500 \text{ N}$$

Why other options are incorrect:

- Option B:** 2500 N results from using incorrect kinetic energy work-energy calculations without accounting for time.
- Option C:** 1500 N corresponds to decelerating the car to rest in 2 seconds.
- Option D:** 1000 N overestimates the required retarding force by a factor of two.

Question #151 Key: (B)PHYSICS
09. Current Electricity

Internal resistance reduces the terminal voltage because it:

CORE CONCEPT & DERIVATION

An electrical power source has internal resistance, which dissipates energy as heat when current flows through its internal electrolyte.

Formula / Rule / Reaction:

$$V_t = E - Ir; \quad P_{\text{internal loss}} = I^2 r$$

Solution:

- When an external circuit draws a current I , a potential drop equal to Ir occurs across the battery's internal resistance r .
- This internal resistance converts electrical energy into heat at a rate of $P = I^2 r$, reducing the available terminal voltage (V_t) below the battery's electromotive force (E).

Why other options are incorrect:

- Option A:** Back EMF is an electromagnetic inductive effect that occurs in inductive loads and rotating electric motors, not across pure internal resistance.
- Option C:** Internal resistance increases total circuit resistance, which decreases the delivered current.
- Option D:** Electromotive force (E) is an intrinsic chemical property of the cell that remains constant regardless of internal resistance.

Question #152 Key: (D)PHYSICS
08. Electrostatics

The force between two charges is 28 N in vacuum. If paraffin wax of relative permittivity 2.8 i...

CORE CONCEPT & DERIVATION

Introducing a dielectric medium between electrostatic charges weakens the electric field through molecular polarization.

Formula / Rule / Reaction:

$$F_{\text{medium}} = \frac{F_{\text{vacuum}}}{\epsilon_r}$$

Solution:

- Given vacuum force $F_{\text{vacuum}} = 28 \text{ N}$ and relative permittivity $\epsilon_r = 2.8$.

- Calculate the force in the dielectric medium:

$$F_{\text{medium}} = \frac{28 \text{ N}}{2.8} = 10 \text{ N}$$

Why other options are incorrect:

- Option A:** 25 N underestimates the reduction caused by dielectric shielding.
- Option B:** 20 N corresponds to a relative permittivity of 1.4.
- Option C:** 15 N corresponds to a relative permittivity of approximately 1.87.

Question #153 Key: (C)PHYSICS
04. Rotational & Circular Motion

A body moves along a semicircular path of radius 10 m from one end of the diameter to the other...

CORE CONCEPT & DERIVATION

Distance is the total scalar path length traversed, whereas displacement is the straight-line vector distance between initial and final points.

Formula / Rule / Reaction:

$$\text{Distance } s = \pi r; \quad \text{Displacement } d = 2r$$

$$\text{Ratio} = \frac{s}{d} = \frac{\pi r}{2r} = \frac{\pi}{2}$$

Solution:

- For a semicircular arc of radius $r = 10 \text{ m}$:

$$\text{Distance } s = \pi r = 10\pi \text{ m}$$

- The displacement equals the straight-line diameter connecting the two ends:

$$\text{Displacement } d = 2r = 2(10) = 20 \text{ m}$$

- Taking the ratio of distance to displacement:

$$\frac{s}{d} = \frac{10\pi}{20} = \frac{\pi}{2} \implies \pi : 2$$

Why other options are incorrect:

- Option A:** $\pi : 1$ divides distance by radius instead of diameter.
- Option B:** $1 : \pi$ inverts the ratio and uses radius instead of diameter.
- Option D:** $2 : \pi$ inverts the ratio, placing displacement over distance.

Question #154 Key: (D)PHYSICS
02. Force & Motion

A body is projected with speed v at angle θ and covers horizontal range R . If speed is doubled,...

CORE CONCEPT & DERIVATION

Horizontal range for a projectile launched over level ground is proportional to the square of its initial velocity.

Formula / Rule / Reaction:

$$R = \frac{v^2 \sin(2\theta)}{g} \implies R \propto v^2$$

Solution:

- If initial launch speed is doubled ($v' = 2v$) at an unchanged launch angle θ :

$$R' = \frac{(2v)^2 \sin(2\theta)}{g} = \frac{4v^2 \sin(2\theta)}{g} = 4R$$

- The new horizontal range is four times the original range ($4R$).

Why other options are incorrect:

- Option A:** Range is proportional to velocity squared, so it increases rather than decreasing.
- Option B:** Launch speed directly affects horizontal distance, so the range cannot remain unchanged.
- Option C:** $2R$ assumes a linear relationship with velocity, overlooking the quadratic dependence (v^2).

Question #155 Key: (C)PHYSICS
02. Force & Motion

A ball of mass m strikes a wall and rebounds with the same speed in the opposite direction. The...

CORE CONCEPT & DERIVATION

Linear momentum is a vector quantity; reversing the velocity direction during a collision produces a change in momentum equal to the vector difference between initial and final values.

Formula / Rule / Reaction:

$$\Delta \vec{p} = \vec{p}_f - \vec{p}_i$$

Solution:

- Let the initial direction toward the wall be positive: $\vec{p}_i = +mv \hat{i}$.
- After an elastic rebound, the ball moves in the opposite direction: $\vec{p}_f = -mv \hat{i}$.
- Calculate change in momentum:

$$\Delta \vec{p} = \vec{p}_f - \vec{p}_i = (-mv) - (+mv) = -2mv$$

Why other options are incorrect:

- Option A:** 0 confuses momentum with kinetic energy, ignoring the direction change in the vector quantity.
- Option B:** mv represents the scalar magnitude of initial momentum, not the change.
- Option D:** $-mv$ is the final momentum, failing to subtract the initial momentum.

Question #156 Key: (A)PHYSICS
04. Rotational & Circular Motion

The angle formed at the center of a circle as a body moves from one position to another is:

CORE CONCEPT & DERIVATION

Rotational kinematics defines rotational motion by measuring the angular angle swept out relative to a central rotation axis.

Formula / Rule / Reaction:

$$\Delta \theta = \frac{\Delta s}{r} \text{ (radians)}$$

Solution:

- Angular displacement is defined as the angle subtended at the center of circular curvature by an object moving along the circumference from an initial position to a final position.
- It is expressed in radians, degrees, or revolutions.

Why other options are incorrect:

- Option B:** Angular velocity is the time rate of change of angular displacement ($\omega = d\theta/dt$).
- Option C:** Angular acceleration is the time rate of change of angular velocity ($\alpha = d\omega/dt$).
- Option D:** Angular momentum is the cross product of position vector and linear momentum ($\vec{L} = \vec{r} \times \vec{p}$).

Question #157 Key: (C)PHYSICS
06. Fluid Dynamics

In laminar flow of fluid, its adjacent layers:

CORE CONCEPT & DERIVATION

Laminar (streamline) flow occurs when fluid particles move along parallel paths without macroscopic mixing between adjacent layers.

Formula / Rule / Reaction:

$$\text{Reynold's Number } N_R < 2000 \implies \text{Laminar flow (Smooth parallel shear layers)}$$

Solution:

- In laminar flow, the fluid travels in smooth, orderly, parallel streamlines.
- Adjacent fluid laminae slide smoothly past each other without lateral mixing or turbulent cross-currents.

Why other options are incorrect:

- Option A:** While internal shear stress (viscosity) exists between layers, laminar flow is defined by layers sliding smoothly past one another.
- Option B:** Fluid mixing between adjacent layers is the defining characteristic of turbulent flow.
- Option D:** Laminar flow is the direct opposite of turbulent flow.

Question #158 Key: (A)PHYSICS
08. ElectrostaticsA point lies 3 m from +5 μC and 4 m from -3 μC . The direction of net electric field is:**CORE CONCEPT & DERIVATION**

The electric field vector from a point charge points radially outward from positive charges and radially inward toward negative charges, with magnitude governed by Coulomb's law.

Formula / Rule / Reaction:

$$E = \frac{k|q|}{r^2}$$

Solution:

- Calculate field magnitude due to $q_1 = +5 \mu\text{C}$ at distance $r_1 = 3 \text{ m}$:

$$E_1 = \frac{k(5 \times 10^{-6})}{(3)^2} = \frac{5}{9} \times 10^{-6} \text{ k} \approx 0.556 \times 10^{-6} \text{ k} \quad (\text{Directed away from } +5 \mu\text{C})$$

- Calculate field magnitude due to $q_2 = -3 \mu\text{C}$ at distance $r_2 = 4 \text{ m}$:

$$E_2 = \frac{k(3 \times 10^{-6})}{(4)^2} = \frac{3}{16} \times 10^{-6} \text{ k} \approx 0.188 \times 10^{-6} \text{ k} \quad (\text{Directed toward } -3 \mu\text{C})$$

- Because E_1 is approximately three times stronger than E_2 , the field from the positive charge dominates, pointing away from the +5 μC charge.

Why other options are incorrect:

- Option B:** The electric field of a positive charge points radially away from the charge, never toward it.
- Option C:** The electric field of a negative charge points toward the negative charge, never away from it.
- Option D:** The fields do not form equal-magnitude perpendicular vectors that would result in a normal vector sum.

Question #159 Key: (A)PHYSICS
06. Fluid Dynamics

The increase in kinetic energy associated with decreased pressure of a fluid in a horizontal pl...

CORE CONCEPT & DERIVATION

Bernoulli's equation applies conservation of energy to ideal, incompressible fluids in steady streamline flow.

Formula / Rule / Reaction:

$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant} \implies \text{In horizontal pipe: } P + \frac{1}{2}\rho v^2 = \text{constant}$$

Solution:

- In a horizontal pipe (constant h), Bernoulli's equation reduces to $P + \frac{1}{2}\rho v^2 = \text{constant}$.
- When the fluid enters a constricted section, its velocity (and kinetic energy $\frac{1}{2}\rho v^2$) increases.
- To conserve total energy, the static fluid pressure P must decrease, which is the direct statement of Bernoulli's principle.

Why other options are incorrect:

- Option B:** The equation of continuity ($A_1 v_1 = A_2 v_2$) relates cross-sectional area to flow velocity based on conservation of mass, without incorporating pressure.
- Option C:** Pascal's principle states that pressure applied to an enclosed static fluid is transmitted undiminished in all directions.
- Option D:** Torricelli's theorem calculates the efflux speed of a liquid exiting an orifice under gravity.

Question #160 Key: (C)PHYSICS
10. Electromagnetism

An electron is projected along the positive x-axis in a magnetic field lying in the xz-plane. T...

CORE CONCEPT & DERIVATION

The magnetic Lorentz force on a charged particle is given by the cross product of its velocity vector and the magnetic field vector, accounting for charge sign.

Formula / Rule / Reaction:

$$\vec{F}_B = q(\vec{v} \times \vec{B}) = -e(\vec{v} \times \vec{B})$$

Solution:

- The electron moves along the positive x-axis: $\vec{v} = v \hat{i}$.
- The magnetic field lies in the xz-plane: $\vec{B} = B_x \hat{i} + B_z \hat{k}$.
- Evaluate the cross product:
- $\vec{v} \times \vec{B} = (v \hat{i}) \times (B_x \hat{i} + B_z \hat{k}) = v B_z (\hat{i} \times \hat{k}) = -v B_z \hat{j}$
- Because an electron carries a negative charge ($q = -e$):
- $\vec{F}_B = -e(-v B_z \hat{j}) = +ev B_z \hat{j}$
- The resulting magnetic force acts along the y-axis, perpendicular to the xz-plane.

Why other options are incorrect:

- Option A:** The magnetic force is always perpendicular to the velocity vector ($\vec{F} \perp \vec{v}$), so it cannot act along the x-axis.
- Option B:** The force cannot act along the line of motion (the x-axis).
- Option D:** The negative charge of the electron reverses the direction from $-\hat{j}$ to $+\hat{j}$, directing it along the positive y-axis.

Question #161 Key: (A)PHYSICS
10. ElectromagnetismThe magnetic flux through a 1 m^2 loop in 0.5 T field is same as through 0.5 m^2 in what field?**CORE CONCEPT & DERIVATION**

Magnetic flux is defined as the scalar dot product of the magnetic field vector and the area vector normal to the loop.

Formula / Rule / Reaction:

$$\Phi = \vec{B} \cdot \vec{A} = BA \cos(\theta)$$

Solution:

- Initial flux (normal entry where $\theta = 0^\circ$):
- $\Phi_1 = B_1 A_1 \cos(0^\circ) = (0.5 \text{ T})(1.0 \text{ m}^2)(1) = 0.5 \text{ Wb}$
- For the second loop with area $A_2 = 0.5 \text{ m}^2$, set $\Phi_2 = \Phi_1 = 0.5 \text{ Wb}$:
- $\Phi_2 = B_2(0.5) \cos(0^\circ) = 0.5 \implies B_2 = \frac{0.5}{0.5} = 1.0 \text{ T}$
- Therefore, a 1.0 T field oriented normal to the surface ($\theta = 0^\circ$) produces the same flux of 0.5 Wb .

Why other options are incorrect:

- Option B:** At 60° , $\cos(60^\circ) = 0.5$, yielding $\Phi = (1.0)(0.5)(0.5) = 0.25 \text{ Wb}$.
- Option C:** At 90° , $\cos(90^\circ) = 0$, yielding zero flux.
- Option D:** At 90° , $\cos(90^\circ) = 0$, yielding zero flux.

Question #162 Key: (A)PHYSICS
06. Fluid Dynamics

A 10 kg body falling through viscous medium reaches terminal velocity. The net force on body is...

CORE CONCEPT & DERIVATION

Terminal velocity represents a state of dynamic translational equilibrium where net external force is zero.

Formula / Rule / Reaction:

$$v = \text{constant} \implies a = \frac{dv}{dt} = 0 \implies F_{\text{net}} = ma = 0$$

Solution:

- At terminal velocity, the downward force of gravity (weight $W = mg = 98 \text{ N}$) is balanced by the upward viscous drag force (F_d) and buoyant force.
- Because the opposing forces are equal in magnitude and opposite in direction:

$$F_{\text{net}} = W - F_d = 98 \text{ N} - 98 \text{ N} = 0 \text{ N}$$

Why other options are incorrect:

- Option B:** 9.8 N is a non-zero value, which would cause ongoing acceleration.
- Option C:** 98 N is the gravitational weight of the body, which is balanced by drag at terminal velocity rather than acting unopposed.
- Option D:** 980 N is an order of magnitude too large.

Question #163 Key: (C)PHYSICS
09. Current Electricity

The temperature coefficient of a conductor is zero. This means resistance:

CORE CONCEPT & DERIVATION

The fractional change in electrical resistance with temperature is governed by the temperature coefficient of resistance (α).

Formula / Rule / Reaction:

$$R_T = R_0(1 + \alpha \Delta T)$$

Solution:

- The relationship between resistance and temperature is $R_T = R_0(1 + \alpha \Delta T)$.
- If the temperature coefficient is zero ($\alpha = 0$):

$$R_T = R_0(1 + 0) = R_0$$

- The electrical resistance remains constant regardless of temperature changes (as observed in standard resistance alloys like constantan and manganin).

Why other options are incorrect:

- Option A:** Resistance increases with temperature only when α is positive, as in standard metals.
- Option B:** Resistance decreases with temperature only when α is negative, as in intrinsic semiconductors.
- Option D:** Zero resistance defines superconductors below their critical temperature, which is distinct from having a zero temperature coefficient.

Question #164 Key: (C)PHYSICS
05. Waves

The path difference between two sound waves = 100 cm; wavelength = 50 cm. The waves produce:

CORE CONCEPT & DERIVATION

Constructive interference occurs when two coherent waves meet in phase with a path difference equal to an integer multiple of their wavelength.

Formula / Rule / Reaction:

$$\Delta x = n\lambda \implies \text{Constructive Interference (Maximum Amplitude)}$$

$$\Delta x = (n + \frac{1}{2})\lambda \implies \text{Destructive Interference (Zero Amplitude / Silence)}$$

Solution:

- Given path difference $\Delta x = 100 \text{ cm}$ and wavelength $\lambda = 50 \text{ cm}$:

$$\frac{\Delta x}{\lambda} = \frac{100 \text{ cm}}{50 \text{ cm}} = 2 = n \quad (\text{where } n \text{ is an integer})$$

- Because the path difference is an exact integer multiple of the wavelength ($\Delta x = 2\lambda$), the waves undergo fully constructive interference.

- The acoustic wave amplitudes add together, producing maximum intensity and perceived loudness.

Why other options are incorrect:

- Option A:** Beats require two sound waves with slightly different frequencies, whereas these waves share the same wavelength and frequency.
- Option B:** An echo is the distinct reflection of sound from a distant boundary.
- Option D:** Silence requires destructive interference, which occurs only at half-integer path differences ($\Delta x = (n + 0.5)\lambda$).

Question #165 Key: (C)PHYSICS
05. Waves

Potential energy decreases during:

CORE CONCEPT & DERIVATION

Elastic potential energy stored in a spring is proportional to the square of its displacement from equilibrium.

Formula / Rule / Reaction:

$$U_s = \frac{1}{2}kx^2$$

Solution:

- Elastic potential energy depends on displacement x from equilibrium according to $U_s = \frac{1}{2}kx^2$.

- When a stretched spring is released, restoring forces pull it back toward $x = 0$.

- As displacement x decreases, stored elastic potential energy decreases as it converts into kinetic energy.

Why other options are incorrect:

- Option A:** Compressing a spring increases displacement (x), which increases stored potential energy.
- Option B:** Stretching a spring increases displacement (x), which increases stored potential energy.
- Option D:** Holding the spring fixed at maximum extension keeps potential energy constant at its peak value.

Question #166 Key: (C)PHYSICS
03. Work & EnergyA diver of mass m at depth h below sea level. Gravitational potential energy is:**CORE CONCEPT & DERIVATION**

Gravitational potential energy depends on position relative to an arbitrary reference datum where potential energy is defined as zero.

Formula / Rule / Reaction:

$$U(y) = mgy \Rightarrow \text{Taking sea level as reference datum: } y = 0, U = 0$$

Solution:

- Setting sea level as the zero potential energy reference plane ($y = 0$):
- Points located at a depth h below this reference datum have a negative vertical coordinate: $y = -h$.

- Calculating gravitational potential energy:

$$U = mg(-h) = -mgh$$

Why other options are incorrect:

- **Option A:** 0 potential energy is defined at sea level itself, not below it.
- **Option B:** $+mgh$ represents gravitational potential energy at an elevation h above sea level.
- **Option D:** $2mgh$ doubles the elevation value without physical justification.

Question #167 Key: (C)PHYSICS
03. Work & EnergyA constant force F acts on a body and displaces it by Δd in time Δt . The rate at which work is ...**CORE CONCEPT & DERIVATION**

Power is the time rate at which work is performed on a system.

Formula / Rule / Reaction:

$$P = \frac{\Delta W}{\Delta t} = \frac{\vec{F} \cdot \Delta \vec{d}}{\Delta t} = \vec{F} \cdot \vec{v}$$

Solution:

- Work done by the constant force is given by $\Delta W = F \times \Delta d$.
- The rate of doing work (power) is the work done divided by elapsed time:

$$P = \frac{F \times \Delta d}{\Delta t}$$

Why other options are incorrect:

- **Option A:** $F \times \Delta d$ calculates total work done, not the time rate of work.
- **Option B:** $F \times \Delta t$ represents impulse (change in linear momentum), not power.
- **Option D:** Inverts time and displacement, which is dimensionally incorrect for power.

Question #168 Key: (B)PHYSICS
01. Vectors & EquilibriumFor vectors $A = 2i + 3j$ and $B = -6i + 4j$, the angle between them is:**CORE CONCEPT & DERIVATION**

The angle between two vectors is determined using their scalar dot product and component magnitudes.

Formula / Rule / Reaction:

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y = |\vec{A}| |\vec{B}| \cos(\theta)$$

Solution:

- Calculate dot product:

$$\vec{A} \cdot \vec{B} = (2)(-6) + (3)(4) = -12 + 12 = 0$$

- Because $\vec{A} \cdot \vec{B} = 0$, $\cos(\theta) = 0$, which corresponds to an angle of $\theta = 90^\circ$.

- **Exam note:** This item appears as an authentic repeat in the original administered paper.

Why other options are incorrect:

- **Option A:** 0° requires parallel vectors with a positive non-zero dot product.
- **Option C:** 120° would require an obtuse negative dot product of $-0.5|\vec{A}||\vec{B}|$.
- **Option D:** 180° requires antiparallel vectors with a dot product of $-|\vec{A}||\vec{B}|$.

Question #169 Key: (B)PHYSICS
05. Waves

The phenomenon of interference of sound waves requires:

CORE CONCEPT & DERIVATION

Sustained, observable interference patterns require waves to maintain a constant phase relationship over time.

Formula / Rule / Reaction:

$$\Delta\phi(t) = \text{constant} \Rightarrow \text{Coherent sources (Identical frequency and wavelength)}$$

Solution:

- For two sound waves to produce stable, stationary nodes and antinodes, the emitting sources must be coherent.
- Coherent sources emit waves with identical frequencies and a constant phase difference over time.

Why other options are incorrect:

- **Option A:** Sources with different frequencies produce time-varying beats rather than a stationary interference pattern.
- **Option C:** A single source cannot interfere with itself without secondary path division.
- **Option D:** A single source with a reflector can produce standing waves, but the fundamental requirement for two-wave interference is source coherence.

Question #170 Key: (B)PHYSICS
07. ThermodynamicsA gas expands from 1 m^3 to 3 m^3 at constant pressure of 2 Pa . Work done is:**CORE CONCEPT & DERIVATION**

Isobaric expansion work performed by an expanding gas equals the constant external pressure multiplied by the change in volume.

Formula / Rule / Reaction:

$$W = P\Delta V = P(V_f - V_i)$$

Solution:

- Given pressure $P = 2\text{ Pa}$, initial volume $V_i = 1\text{ m}^3$, and final volume $V_f = 3\text{ m}^3$.

- Calculate volume change:

$$\Delta V = 3\text{ m}^3 - 1\text{ m}^3 = 2\text{ m}^3$$

- Calculate work done:

$$W = P\Delta V = (2\text{ Pa})(2\text{ m}^3) = 4\text{ J}$$

Why other options are incorrect:

- Option A:** 2 J results from multiplying by 1 m^3 instead of the actual 2 m^3 volume change.
- Option C:** 6 J incorrectly uses the final volume $V_f = 3\text{ m}^3$ directly without subtracting the initial volume.
- Option D:** 8 J overestimates the work by a factor of two.

Question #171 Key: (C)PHYSICS
12. Alternating Current

If frequency of AC is doubled, the inductive reactance will:

CORE CONCEPT & DERIVATION

Inductive reactance measures the opposition an inductor offers to alternating current, which is directly proportional to signal frequency.

Formula / Rule / Reaction:

$$X_L = 2\pi fL \implies X_L \propto f$$

Solution:

- Inductive reactance is directly proportional to AC frequency: $X_L = 2\pi fL$.
- If the supply frequency is doubled ($f' = 2f$) while keeping inductance L constant:

$$X'_L = 2\pi(2f)L = 2(2\pi fL) = 2X_L$$

- The inductive reactance doubles.

Why other options are incorrect:

- Option A:** Reactance depends directly on frequency, so it cannot remain unchanged.
- Option B:** Capacitive reactance ($X_C = 1/(2\pi fC)$) is halved when frequency doubles, but inductive reactance doubles.
- Option D:** Inductive reactance becomes zero only at zero frequency (DC), not with increasing AC frequency.

Question #172 Key: (B)LOGICAL REASONING
05. Categorical Syllogisms & Overlapping Sets

Statements: All melons are apples. No apples are mangoes. Conclusions: I. All melons are mangoes...

CORE CONCEPT & DERIVATION

Deductive syllogistic reasoning evaluates whether conclusions follow validly from stated premises using set theory relationships.

Formula / Rule / Reaction:

$$\text{Melons} \subset \text{Apples}; \quad \text{Apples} \cap \text{Mangoes} = \emptyset \implies \text{Melons} \cap \text{Mangoes} = \emptyset$$

Solution:

- Premise 1 establishes that the set of melons is entirely contained within the set of apples ($\text{Melons} \subset \text{Apples}$).
- Premise 2 establishes that the set of apples shares no elements with the set of mangoes (disjoint sets: $\text{Apples} \cap \text{Mangoes} = \emptyset$).
- Evaluation of Conclusion I: Because all melons are apples and no apples are mangoes, no melons can be mangoes. Conclusion I is false.
- Evaluation of Conclusion II: 'No apples are mangoes' directly implies that apples are not mangoes. Conclusion II is valid, matching Option B.

Why other options are incorrect:

- Option A:** Directly contradicts both premises because the two sets are completely disjoint.
- Option C:** Incorrect because Conclusion I is false.
- Option D:** Incorrect because Conclusion II is logically valid and directly supported by the premises.

Question #173 Key: (D)LOGICAL REASONING
12. Linear Ranking, Ordering & Inequalities

If Amna is older than Muneeb, and Muneeb is younger than Jaffar, then Amna is:

CORE CONCEPT & DERIVATION

Transitive inequality relations require a consistent directional comparison across all terms to establish an ordered sequence.

Formula / Rule / Reaction:

$$\text{Amna} > \text{Muneeb} \quad \text{and} \quad \text{Jaffar} > \text{Muneeb}$$

Solution:

- Given: $\text{Amna} > \text{Muneeb}$.
- Given: $\text{Muneeb} < \text{Jaffar}$, which means $\text{Jaffar} > \text{Muneeb}$.
- Both Amna and Jaffar are older than Muneeb, but no relationship is provided between Amna and Jaffar.
- Amna could be older than, younger than, or the exact same age as Jaffar. There is not enough information to determine their relative ages.

Why other options are incorrect:

- Option A:** Amna may be younger than Jaffar while still being older than Muneeb (e.g., Jaffar = 25, Amna = 20, Muneeb = 15).
- Option B:** Amna may be older than Jaffar (e.g., Amna = 30, Jaffar = 25, Muneeb = 15).
- Option C:** Amna and Jaffar could be the exact same age (e.g., Amna = 20, Jaffar = 20, Muneeb = 15).

Question #174 Key: (D)LOGICAL REASONING
13. Blood Relations & Kinship

In a family of six members: • P is the father of Q • R is the mother of Q • S is the sister of ...

CORE CONCEPT & DERIVATION

Kinship logic identifies family relationships by mapping parent-offspring lines and sibling connections.

Formula / Rule / Reaction:

Uncle = Brother of one's father or mother

Solution:

- P is the father of Q.
- T is the brother of P.
- The brother of a person's father is their paternal uncle.
- Therefore, T is the uncle of Q.

Why other options are incorrect:

- **Option A:** P is the father of Q.
- **Option B:** R is the mother of Q.
- **Option C:** S is the sister of Q.

Question #175 Key: (B)LOGICAL REASONING
13. Blood Relations & Kinship

If A is the mother of B and C is the child of B, then what is the relationship between A and C?

CORE CONCEPT & DERIVATION

Generational genealogical relationships identify relatives across two generations of direct lineal descent.

Formula / Rule / Reaction:

Mother of an individual's parent = Grandmother

Solution:

- A is the mother of B (Generation 1 to Generation 2).
- B is the parent of C (Generation 2 to Generation 3).
- Because A is the mother of C's parent, A is the grandmother of C.

Why other options are incorrect:

- **Option A:** An aunt is the sister of one's parent, not the mother of one's parent.
- **Option C:** A sister belongs to the same generation as C.
- **Option D:** A cousin is the child of one's aunt or uncle, which is a collateral rather than direct lineal relationship.

Question #176 Key: (A)LOGICAL REASONING
07. Number Series & Numerical Progressions

Which number comes in the missing place? 120, 119, 117, 114, 110, ____

CORE CONCEPT & DERIVATION

A mathematical series is solved by identifying the pattern in the differences between consecutive terms.

Formula / Rule / Reaction:

$$x_n = x_{n-1} - n \quad (\text{where } n = 1, 2, 3, 4, 5, \dots)$$

Solution:

- Calculate differences between consecutive terms:

$$120 - 119 = 1$$

$$119 - 117 = 2$$

$$117 - 114 = 3$$

$$114 - 110 = 4$$

- The subtraction value increases by 1 at each step. Therefore, the next step subtracts 5:

$$110 - 5 = 105$$

Why other options are incorrect:

- **Option B:** 100 subtracts 10 instead of 5.
- **Option C:** 95 subtracts 15 instead of 5.
- **Option D:** 107 subtracts 3 instead of 5.

Question #177 Key: (B)LOGICAL REASONING
08. Letter Series & Coding-Decoding

A spying agent coded POWER as QPXFS. Using this pattern, what will be the code for GUNBD?

CORE CONCEPT & DERIVATION

Caesar cipher substitution shifts each letter in a plaintext word forward by a fixed alphabetical position.

Formula / Rule / Reaction:

$$\text{Plaintext letter} + 1 = \text{Ciphertext letter}$$

Solution:

- Analyze the coding pattern for POWER to QPXFS:

$$P \xrightarrow{+1} Q; \quad O \xrightarrow{+1} P; \quad W \xrightarrow{+1} X; \quad E \xrightarrow{+1} F; \quad R \xrightarrow{+1} S$$

- Apply the identical +1 forward shift to GUNBD:

$$G \xrightarrow{+1} H$$

$$U \xrightarrow{+1} V$$

$$N \xrightarrow{+1} O$$

$$B \xrightarrow{+1} C$$

$$D \xrightarrow{+1} E$$

- The resulting ciphertext is HVOCE.

Why other options are incorrect:

- Option A:** Shifts N to P (+2) instead of O (+1).
- Option C:** Leaves N unshifted as N (+0) instead of shifting to O (+1).
- Option D:** Shifts B to D (+2) instead of C (+1).

Question #178 Key: (A)LOGICAL REASONING
03. Courses of Action & Decision-Making

A new virus is spreading rapidly in the city. The government should impose temporary travel res...

CORE CONCEPT & DERIVATION

Epidemiological management uses movement restrictions to reduce contact rates and lower the basic reproduction number of an infectious pathogen.

Formula / Rule / Reaction:

$$\downarrow \text{Human mobility} \Rightarrow \downarrow \text{Effective reproduction number } R_t \Rightarrow \text{Suppression of outbreak}$$

Solution:

- Infectious airborne and contact-transmissible viruses spread along human transit corridors.
- Imposing temporary travel restrictions reduces contact rates between infected and unexposed populations, helping contain geographic spread and flattening the infection curve.

Why other options are incorrect:

- Option B:** Promoting travel during an acute outbreak increases contact rates and accelerates viral spread, overwhelming healthcare infrastructure.
- Option C:** Movement restrictions directly reduce contact opportunities, which directly lowers transmission rates.
- Option D:** Disregarding health guidance undermines public containment efforts and worsens outbreak spread.

Question #179 Key: (D)LOGICAL REASONING
10. Percentages, Ratios & Unit Calculations

A tank can hold 240 L of water. Currently, water is filled to one-third of its capacity. How mu...

CORE CONCEPT & DERIVATION

Remaining volumetric capacity equals total capacity minus the currently occupied volume.

Formula / Rule / Reaction:

$$V_{\text{remaining}} = V_{\text{total}} - V_{\text{current}} = V_{\text{total}} \left(1 - \frac{1}{3}\right) = \frac{2}{3} V_{\text{total}}$$

Solution:

- Total capacity $V_{\text{total}} = 240 \text{ L}$.

- Current volume filled:

$$V_{\text{current}} = \frac{1}{3} \times 240 \text{ L} = 80 \text{ L}$$

- Calculate remaining capacity:

$$V_{\text{remaining}} = 240 \text{ L} - 80 \text{ L} = 160 \text{ L}$$

Why other options are incorrect:

- Option A:** 60 L represents one-fourth of the total tank capacity.
- Option B:** 80 L is the volume of water currently in the tank, not the remaining capacity.
- Option C:** 100 L is an incorrect calculation.

Question #180 Key: (A)LOGICAL REASONING
08. Letter Series & Coding-Decoding

M, N, P, Q, S, ??

CORE CONCEPT & DERIVATION

Alphabetical letter series follow recurring numerical shift patterns based on standard letter positions (A=1 to Z=26).

Formula / Rule / Reaction:

$$\text{Alternating forward step pattern: } +1, +2, +1, +2, +1, \dots$$

Solution:

- Map each letter to its alphabetical position:

$$M = 13$$

$$N = 14 \quad (+1)$$

$$P = 16 \quad (+2)$$

$$Q = 17 \quad (+1)$$

$$S = 19 \quad (+2)$$

- The series alternates between +1 and +2. Following +2, the next step is +1:

$$19 + 1 = 20 \Rightarrow T$$

Why other options are incorrect:

- Option B:** U has position 21, which incorrectly applies a +2 shift instead of +1.
- Option C:** V has position 22, which would require an unaligned +3 shift.
- Option D:** W has position 23, which does not fit the alternating pattern.